

Unidad de Políticas Comparadas (CSIC)
Working Paper 02-19

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Unidad de Políticas Comparadas, SPRITTE

(Spanish Policy Research in Innovation & Technology, Training & Education)

September 2002

Coping with environmental pressures: Public Research Organisations responses to funding crises

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Abstract

The research system is highly dependent upon the resources provided by the political system. Rising costs of research projects and the emergence of financial problems in government have triggered a reduction in direct support to public research organisations (PRO). The aim of this paper is to analyse how a group of Spanish public research organisations affected by the reduction in direct transfers of State funds have reacted to this situation. By reviewing the PROs' responses, an institutionalist argument is built up based on the degree and type of autonomy which the centres and researchers enjoy. Factors which explain the diversity in responses of the centres in their funding strategies are: a) the political autonomy of the PROs with respect to their tutelary Ministries, and b) the autonomy of the researchers within the organisation, the nature of the individual incentive programmes and their level of dependence on collective resources.

Keywords: Public Research Organisations, R&D Funding, Commercialisation of research; Organisational Adaptation.

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1 Introduction

Governments have been developing research policies for over 50 years; the S&T policy domain has consolidated. Policies in favour of R&D have changed and evolved (Elzinga and Jamison, 1995; Sanz Menéndez and Borrás, 2001): The first interventions promoted research by creating public research centres; the sixties and the seventies saw the introduction of mechanisms and incentives by which universities and companies could further their research activities, first by means of the *Research Councils* (Rip, 1994) and later via *strategic R&D programmes* (Irvine and Martin, 1984); today, various forms of government intervention coexist with different emphasis across countries.

Research is an activity which is extraordinarily dependent upon external resources from the political system (Solingen, 1993), particularly the public R&D centres are very dependent on *governmental resources*. Research activity is very sensitive to turbulent environments, changes in their situation, political crises, and even to economic recessions that affect the availability of public money. In fact, the reduction in the institutional funding¹ that occurred in the nineties in many countries proved to be a problem for the furthering of research in public research organisations, threatening their very existence.

This paper presents a study of the responses of the public research organisations (PROs)² to these changes in their environment. More specifically it describes the strategies that public research organisations adopted in order to cope with the reduction in direct public financing. Some organisations' responses were simply **compliant**, while others were very **active**. Given that responses were diverse, the second question is how to explain this when the financial problems being faced were quite general. Thus, the objective of this paper is the analysis of the public research performing organisations in Spain and especially their ability to deal with a changing financial environment.

Our study covers the analysis of eight publicly owned research organisations in Spain (see Table 1), which are accountable to specific Ministries depending on their nature and are important, well established and relatively large organisations³. These organisations, up until the mid-seventies, were the only sites for research in Spain. During the nineties, as a result of the economic recession, there was a reduction of the direct transfers of funds from the Central Government to these research centres. Six of the PROs are only research performing

¹ We are going to use the concept “institutional funding” to refer to the traditional block grant funding to R&D centres as opposed to “external funding” coming from competitive sources, contract research, etc.

² Here we focus in organisations (differentiated), which could be comprised of several research centres and/or laboratories.

³ See: Alonso, Fernández and Sanz-Menéndez (2001), López Facal and Represa (1998), Muñoz *et al.* (1999) or Sanz-Menéndez and Cruz (2001).

organisations, while others resemble Research Councils ⁴. They are also very diverse in mission, size, fields of specialisation, internal organisation, scientific competences and institutional affiliation⁵.

Table 1.- Selected Spanish Public Research Organisations (PROs)

Acronym	English literal translation	Year of creation	Average Staff year 2000	Ministerial affiliation year 2000	Most relevant Areas of Scientific and Technical expertise	Similar organisations in France, Germany, U. K., Italy
CSIC	Higher Council for Scientific Research	1939	9,508	Education and Culture	All kinds of basic and applied research	CNRS, MPG, ---, CNR
CIEMAT	Centre for Energy, Environmental and Technological Research	1948	1,142	Industry and Energy	Energy, nuclear, environment	CEA, KfK, UKAEA, ENEA
IGME	Spanish Institute for Geomining Technology	1859	421	Environment	Geology, mining	BRGM, BfGR, BGS/NERC, SGI
INTA	“Esteban Terradas” National Institute for Aerospace Technology	1942	1,400	Defence	Aeronautic, space, electronic, communications,	CERT-ONERA, DLR, DERA, CIRA
INIA	National Institute for Agriculture and Food Research and Technology	1971	984	Agriculture, Fishing and Food	Animal health, forestry, agriculture food, fito & zoo-genetic resources	INRA, FAL/IPK, BBSRC, ISC/ISZA
IEO	Spanish Institute for Oceanography	1942	460	Agriculture, Fishing and Food	Oceanography, fisheries, aquaculture, marine environment	IFREMER, BfF, DFR, --
ISCIII	“Carlos III” Health Institute	1986	1.054	Health and Consumer Affairs	Health and biomedical research	INSERM, GSF, MRC/NIMR, ISTISAN
CEDEX	Centre for Public Works Studies and Experimentation	1957	735	Public Works	Materials, public works hydrography environment	LCPCCh, BAST, TRLL, ISMES

We begin our paper with a brief literature review; although there is no specific theory for explaining the “response to problems” (Schimank and Stucke, 1994 a), the organisation theory and institutional analysis offer us an analytical framework, built on the “dependence on resources” (Pfeffer and Salancik, 1978) and the “adaptive” responses (March, 1994), in which to situate our study. The third section describes the changes in the Spanish research system, the specific environment within which these organisations function, and their responses to the changes in the levels of institutional funding. The fourth section, in view of the significant variation in the responses by the different organisations, builds up an explanation based on the

⁴ In two of the cases, ISCIII and INIA, the PROs also maintain management functions as “research councils” providing competitive research funds for extramural research which are included in their budgets.

⁵ Since April 2000 some PROs (CSIC, CIEMAT, INIA, IGME and IEO) have changed their ministerial affiliation and today are under the new Ministry of Science and Technology.

degree of autonomy of research actors, both individual and organisational. Finally we construct a typology of strategies of response followed by PROs.

2 How research organisations cope with problems

Universities and firms, as research actors, have attracted the attention of scholars, while little attention have been paid to the systematic study of public research centres⁶. In sociology of science it has been traditional to study the relationship between the cognitive dimension of knowledge production and the research in "action" (Latour and Woolgar, 1979; Knorr-Cetina, 1981), however the focus was not on the organisations themselves.

The changing role of PROs in the research systems has attracted the attention of policy makers (OECD, 1989) as well as scholars in connection with the emergence of new intermediary institutions (van der Meulen and Rip, 1994; Benner and Sandström, 2000). Government-owned R&D centres have been studied in the context of knowledge production units: the research laboratories; few contributions aimed to characterise and understand the dynamic of changes that were based on typologies of R&D laboratories, e.g. the "environmental context taxonomy" (Bozeman and Crow, 1990; Crow and Bozeman 1987 a, b; Crow and Bozeman, 1991), the "compass card of research" (Laredo *et al.*, 1992; Laredo and Mustar, 2000), or the "industrial partnership orientation" of public laboratories (Joly and Mangematin, 1996).

More recently, issues and trends such as privatisation or the shift to private management schemes of government-owned laboratories (Boden *et al.*, 2001), reforms (Dufour and de la Mothe, 2001), increasing pressure for commercialisation and technology transfer (Bozeman, 1994) or the relevance of the S&T policy in shaping the configurations of laboratories (Callon *et al.*, 1992) have been addressed. Analyses have focused on the reactions to political disturbances of research conditions (Schimank and Stucke, 1994 a; Schimank and Stucke, 1994 b) alternatively, on reactions to budget constraints imposed by governments (Alonso, Fernández and Sanz-Menéndez, 2001; Sanz-Menéndez and Cruz, 2001).

Public funding has been a necessary condition for the very existence of the R&D system. Governments delegate research in varying degrees to other organisations or actors which would otherwise lack the financial resources to carry out this research; however, in recent decades, this delegation has taken place in the context of far higher research costs together with a reduction in real terms of the public resources available for this research. Faced with a situation of a relative

⁶ Exceptions are: Cox *et al.* (Editors) (2001), Crow and Bozeman (1998) and research reported by Senker (2000).

lack of financial resources, organisational theory helps to understand PROs' behaviours and their responses to the new external conditions.

This paper is about how the external environment affects and constrains research organisations and how organisations respond to these external constraints. Given that the fortune of the public research organisations depends greatly on the political system, research organisations are characterised as open systems which support themselves through the exchange of resources with their environments (Aldrich, 1979; Meyer and Scott, 1992). Moreover the resource dependence theory (Pfeffer and Salancik, 1978) points out that no organisation is self-sufficient and the need to acquire resources in order to develop its activities creates dependence between the organisation and a number of external actors. The nature and extent of this dependence is determined by the volume of the resources required for what constitutes the core activity of the centre and by the relative abundance of these resources⁷. Resource dependence characterises the research system in several ways, researchers depend upon the knowledge produced by others in order to progress (De Solla Price, 1963) but they are also dependent on economic resources from the political system.

Organisations may work actively to promote their opportunities, thus we could explain short term adaptation and organisational change as reactions to problems, especially when funding is central in terms of organisational survival and competitiveness. Organisations might be understood as coalitions of interests that face an environment of competing, frequently conflicting, demands and that need resources from those environments. The members of the organisations, and particularly but not exclusively their management boards, actively pursue the establishment of ties with the external environment of the organisation, identifying problems, opportunities and threats, they seek favourable exchanges. Thus organisational strategies are developed to cope with external constraints; the concept of "organisational strategy" implies itself the ability of organisations to respond actively.

We would also argue that the bases for this dependence (or its counterpart, autonomy) are of an institutional character which may only be understood by looking at the social bases and the regulations controlling stability and change within organisations (Meyer and Rowan, 1977; Scott, 1995). Given that PROs, as with all organisations, move simultaneously in a number of different environments, the resource dependence approach is useful to understand the responses to changes in the financial environment; however, it is also important to look at the institutional and social environments⁸.

⁷ Dependence is the antithesis of power and the power of one actor over another is inversely proportional to the capacity of that actor to obtain resources outside his relationship with the latter (Emerson, 1962).

⁸ The social environment provides the values and expectations which the organisations must observe.

If the reduction in the public budget devoted to research is thought of as a problem derived from changes in the political and economic environment, there are different feasible adaptive responses which the research centres could apply. Analysis of the mechanisms by which researchers, managers and organisations cope with these problems is carried out from an institutional perspective, a perspective which, nevertheless, takes into consideration the organisational actors and the means by which they choose a particular pattern of behaviour from the different available strategies, according to their interests, resources, opportunity structures, etc.

It may be expected that PROs, facing a common threat will undertake similar forms of action. Organisations that belong to the same organisational field tend to be isomorphic (DiMaggio and Powell, 1983), particularly if the regulations within which they must function are the same. However, these regulations do not fully explain the institutional context in which the research centres and their investigators are moving. The individual and collective incentives in favour of certain behaviours, the managerial structures of organisations, and the conditions which generate the existence of markets and research users in certain areas are institutional elements which may lead to the divergence rather than convergence.

It may be assumed that the principal objective of the actors involved in research is to assure the continuity of their activities: reproduction. Thus, to answer the problem presented by the reduction in available public funds, researchers and the research centres -represented by their managers- may adopt different patterns of behaviours. The resource dependence approach (Pfeffer and Salancik, 1978) gives us some possible organisational responses to the demands confronted: The possibility of compliance with external constraints, or simple adaptation, as well as the possibility of avoiding influence and thus managing and avoiding dependence. Of the possible expected responses of these publicly owned R&D organisations, there are a number of **relatively passive ones**, specifically those which accept the situation and do not take any form of action which could modify the effects of the change in the environment. Other reactions are more or less active, ranging from the **prevention** of the effects of changes, for which the players have to count on knowing the information before they occur, to **active adaptation**. Organisational theory also tells us about the relevance of individuals in organisations, and we could expect that the way in which active responses take place could have two forms: **individual or collective**. Faced with this politically-induced problem which we are taking as a reference, that of the reduction in direct financing, the organisations collectively, through their directors, or the researchers on an individual basis, may undertake actions aimed at searching for external sources of finance which guarantee the continuation of the activity. The analysis must therefore combine two different levels of action, that of the individual researcher and that of the research centre.

3 Research organisations in their S&T environment

During Franco's dictatorship "the majority of scientific research [in Spain] was carried out in the government centres or institutions (and) from the financial point of view, 85% of the total research expenditure for the country was channelled through seven R&D centres" (OECD, 1964). The Spanish public research centres were institutions set up by the Ministries, that framed their missions, and which were funded from the National Budget. Their employees held civil servant status (though contracted researchers were also present) and their research activities were carried out in line with ministerial interests. Institutional funding was the rule and there were almost no external sources of finance. Moreover institutional restrictions imposed by Ministries also applied and some R&D centres were not allowed to accept external funding (either through contracts or grants) to increase their own budgets. The organisations were managed under a system of bureaucratic hierarchical authority and the allocation of resources to the different projects, units or researchers was based on the discretionary decisions made by the general directors who were appointed by their Ministers.

During the eighties there were significant increases in public spending on research, as well as a change in the provision of economic resources, with increasing emphasis on competitive funding as a way of providing support for research⁹. Despite the large increases in public investment in R&D, government budget appropriations and outlays in R&D (GBAORD) moved from 700 Million ecus in 1980 to 2,360 Million in 1990 (both in prices 1990 PPP), there was a relative loss of weight of the government performing sector with respect to other research sectors. Budgetary expenditure on the public R&D organisations in 1980 represented 57.2% of the total whereas, in 1990, this had fallen to 32.6%.

3.1 INSTITUTIONAL REFORMS

On the period of reference –1980s- institutional and organisational reforms were also in place, affecting both the S&T environment and the research centres themselves, their management structures, goals, etc. The changes in the environment were the consequence of

⁹ The growth in public spending on R&D occurred not so much in terms of increases in institutional funding for the public R&D centres but rather as "competitive financial support", either under "research council funding" or the "strategic R&D programmes" included in the National Plan for R&D. It was a strategy of simultaneously building a "research council system", to provide competitive funding for research actors [through the "General Promotion of Knowledge Program" (PGC), the Health Research Fund (FIS), among others] and a "strategic R&D programming" with scientific priorities consolidated within the National R&D Plan. For a systematic analysis of the research policy changes in Spain see: Sanz-Menéndez (1997).

policies aimed at reorganising government intervention in favour of R&D and, later in the nineties, of the changes in public resources allocated for research.

Furthermore, the government developed policy reforms in the area of science and technology which affected universities¹⁰ and research centres, the objectives and the instruments of public intervention (the establishment of a National Plan for R&D), and even the ways of organising and co-ordinating public activity (the creation of an Inter-Ministerial Commission on Science and Technology - CICYT). A cornerstone of these reforms was the Act on the Promotion and General Co-ordination of Scientific and Technological Research (Act 13/1986), better known as the *Science Act*. This law defined new objectives, rules and the creation of new institutions in the field of science and technology policy¹¹.

Implicit in the changes in the S&T policy was the decision to pressure the PROs to compete for the new public funding and to search for contract research. In the Science Act, the regulations affecting the public research centres were designed to homogenise situations and provide them with flexibility in order to improve their alignment with the priorities of the National Plan. The Act created the new legal status of "Public Research Organisations" (PROs)¹² which were declared subject to a number of common organisational principles and actions; the most important affected: the economic management of the PROs, the flexibility to contract non-civil service researchers and the possibility to create new economic incentives for researchers. The PRO got: a) the status of "autonomous commercial organisations", although they maintained their affiliation with their tutelary Ministry that provided the institutional funding; thus they were able to opt for "external funding, from competitive national or European funds and by the signing of agreements or contracts with companies, to finance their activities; b) the mechanisms by which to contract temporary researchers to carry out R&D projects; and c) the possibility that a proportion of the commercial income derived from contracts signed with firms, for scientific work or technical assessment, could be transferred to individual researchers in the form of productivity bonuses in their salaries.

The new regulations increased the number of alternative strategies for managers and researchers within the R&D organisations under the new institutional framework managers and researchers were confronted with a larger set of options available to respond. They paved the way for the diversification of the sources of funding, they facilitated staff's increases even in

¹⁰ The Act on University Reform was passed in 1983.

¹¹ It was a pressure to align the research agendas in the universities and R&D centres with social and economic requirements by means of "prioritised research" (Sanz-Menéndez, *et al.*, 1993), but also an allocation increase of competitive research funds through systematic scientific evaluation (Sanz-Menéndez, 1995 b) and the promotion of incentives to increase "external funding" (Sanz-Menéndez, 1995 a).

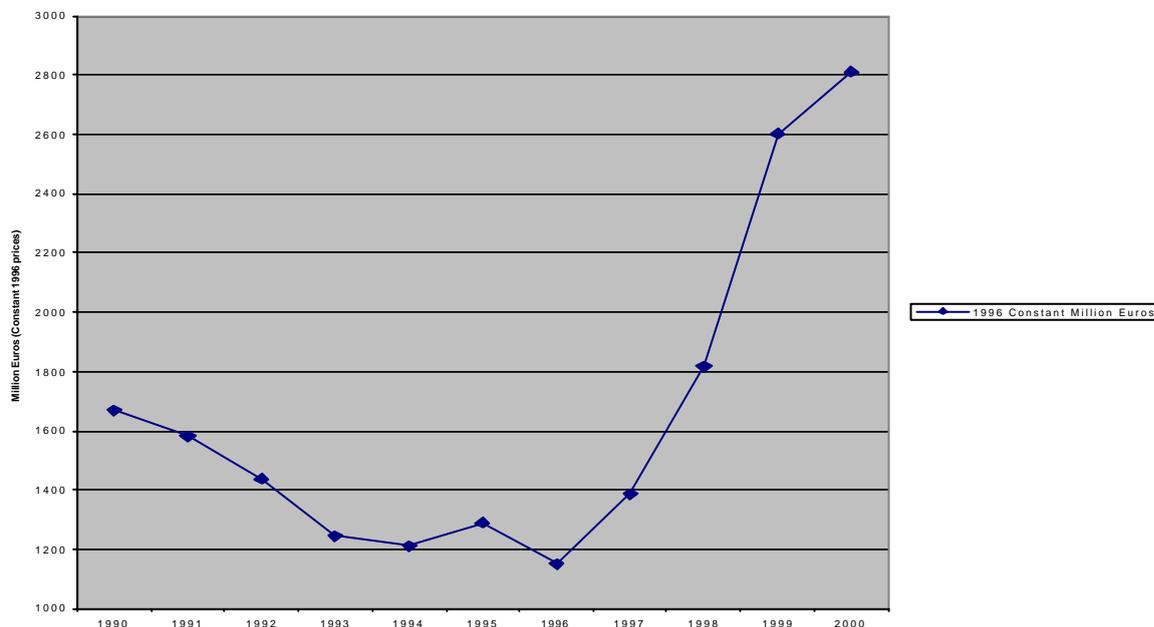
¹² In Spanish: *Organismos Públicos de Investigación (OPIS)*.

years of public austerity, and they created an institutionalised system of individual economic incentives in PROs in the same way that was established for university researchers. The pre-conditions for an increase in the autonomy of the centres and an improvement in their management were then created. However, the implementation of this autonomy was something which the centres had to decide for themselves and obtain from their respective Ministries. Thus, when there was a reduction in the available institutional funding during the nineties, the PROs already held the instruments to respond or at least to adapt to such changes.

3.2 THE FINANCIAL CRISIS IN THE 1990s

While in the eighties there had been a growth in real terms of the funds provided to the R&D centres, in the nineties, the favourable climate for R&D changed with the onset of a period of relative stagnation and even a decline in the public contribution to R&D, as result of the political priority set by the Spanish Government about strict control of public expenditure to reduce public deficit figures¹³ (see Figure 1).

Figure 1. Spanish Total Government R&D appropriations ("Function 54 of the Annual Budget") (Millions euros at constant prices of 1996)



Source: *Presupuestos Generales del Estado* (Spanish Annual Budget), various years.

¹³ Additionally since 1997 the growth of the government R&D budget appropriations (GBAORD), have been produced in Chapter 8 of the National Budget, under the modalities of repayable loans, aimed particularly at businesses, and which have come to represent almost 50% of the total government budget.

In the same way as the changes in the overall R&D budgetary appropriations (GBOARD) worsened at the start of the nineties, so also did the institutional funding of the research centres, which levelled off and even fell, in real terms, showing a slow recovery since 1997.

Table 2. Direct Government Budget Appropriations for *in house* research of Public Research Organisations. Changes over previous year in real terms (constant prices of 1996) and index numbers (1990 = 100) 1990-2001

	1.991	1.992	1.993	1.994	1.995	1.996	1.997	1.998	1.999	2.000
INTA	123,0	159,9	151,7	140,9	135,0	120,2	116,8	116,7	115,2	113,6
CEDEX	96,3	92,8	91,2	88,2	97,4	86,7	86,3	83,0	81,1	77,4
CSIC	88,5	86,2	84,1	79,5	82,2	73,2	76,4	78,7	84,7	90,5
INIA	101,0	100,3	93,3	83,0	82,7	73,6	73,4	75,4	78,1	103,6
IEO	108,9	96,8	98,0	80,4	90,7	80,8	85,7	96,3	110,8	119,5
ISCI	87,3	79,7	70,4	69,1	76,7	68,3	71,6	80,9	84,0	90,8
CIEMAT	97,9	95,5	89,2	78,5	77,2	68,7	71,2	70,7	76,8	82,0
IGME	95,1	76,8	70,5	48,0	44,6	39,7	43,1	42,3	48,1	50,2
All PROs	95,8	96,1	91,7	84,1	86,1	76,6	83,5	85,5	90,7	97,4

Source: *Presupuestos Generales del Estado* (Spanish Annual Budget), various years.

Only in recent years, some of the centres have recovered their 1990 levels of funding, in real terms, but in aggregate terms the institutional funding figures for PROs are still below their 1990 levels (see Table 2), with the exception of INTA, INIA and IEO. In general, between 1991 and 1997, the real annual rates of change in the institutional funding for PROs were negative, with accumulated reductions that vary from 20 to 60%.

Additionally, their fortunes were shaped by their tutelary Ministry. The PROs dependent on the Ministry of Industry suffered greater relative cuts compared to those depending on Defence, Agriculture and Education. Ministerial dependence introduces variance because the process which determines the “budgetary cuts” is fixed in each Ministry. In those years, the “pro-business” ideology and that of the reduction in the direct involvement in research was supported by the Ministry of Industry which did not wish to have its own research centres but rather to promote private R&D. On the other side, the two PROs (INIA and IEO) that most rapidly recovered the institutional funding levels of 1990 were, at that time, under the Ministry of Agriculture. However, a further clarification is needed with respect to INTA. The INTA received an increase in its budget between 1990 and 1992, allowing it to initiate a programme of mini-satellites to give Spain the capacity to launch and produce them. In this case, its alignment with Ministry of Defence objectives became an advantage in terms of increasing budgets and net transfers.

3.3 EXTERNAL FUNDING AS A RESPONSE

The organisational and institutional changes and, above all, the levelling off of budgetary credits transferred directly to the PROs became a strong pressure to change. To what extent did this new environment lead to a response of the research organisations concerning the funding of their activities?

We have used the increase of external funding¹⁴ of the centres as an indicator both of the type of response to the changes and of the degree of adaptation of the centres to the new economic environment. What interests us, firstly, is to determine how the increase in external funding may be explained and to what extent these changes were just the result of, or reaction to the difficulties and to the reductions in direct funding.

If we look at the external funding evolution, there was considerable variation in the PROs responses to the new environment, both in the type of strategy adopted and in the intensity of the reaction. Some PROs started to commercialise their knowledge or to diversify their sources of income, while others, in contrast, hardly looked for external funding despite the opportunities created by the new regulations. Thus, in 2000 some centres obtain almost one third of their total budget from sources other than institutional funding, while other maintain status quo. The CSIC is an extreme case as, in one decade, the proportion of non institutional funding in the total budget of expenses had doubled implying that for every two euros transferred to the CSIC by the State, its researchers were able to generate almost another one to support their research activities. At the other end of the spectrum are the PROs, such as the ISCIII, the IGME or the CEDEX, with very limited levels of external funding for performing R&D (see table 3), the data relating to the responses of the centres are presented and also the 1996 institutional funding levels in comparison with the situation in 1990.

¹⁴ We will use the term “external funding” or “non-budgetary income” to refer to the PROs income not coming from institutional funding. The type and degree of intensity of the responses to problems of funding is analysed by means of a “proxy” which is the percentage of the final total expenditure budget which is funded by resources coming from “commercial operations”, not from direct transfer from the National Budget at the beginning of each year.

Table 3. Some indicators of the financial stress and responses of Spanish PROs s

Acronym	Institutional Funding for Research Performing Organisations PROs, 2000 (Millions Euros)	Institutional funding in real terms. 1996 [comparison with the level of 1990. Index numbers (1990= 100)]	External funding as % of total research expenditures [average 1997-2000]	Main Sources of external Funding and relevance in 2000
CSIC	261,8	73.2	31%	National R&D Plan (33%) Framework R&D Programme (33%) Firm's contracts (22%)
CIEMAT	51.9	68.7	25%	Firm's contracts (33%) Framework R&D Programme (32%)
IGME	22.4	39.7	8%	Firm's contracts (50%) Agreements with Public Sector (35%)
INIA	33.1 (*)	73.6	18%	Agriculture R&D Program (25) Agreements with Public Sector (20%) UE Funds (17%) National R&D Plan (15%) Firm's contracts (8%)
IEO	29.7	80.8	14%	Fishing Secretariat (40%) Framework R&D Programme (30%)
INTA	88.3	120.2	20%	Firm's contracts (50%) Agreements with Public Sector (30%) Other international Funds (20%)
ISCIH	68.1 (**)	68.3	7 %	Health research Fund (FIS) (40%) National R&D Plan (21%) Framework R&D Programme (15%)
CEDEX	33.0	86.7	5 %	Agreements with Public Sector (35%) Framework R&D Programme (30%)

(*) It excludes 9 million euros of they "research funding agency mission, offered through open invitation to bids for which the researchers of the INIA make compete.

(**) Excludes the Health Research Fund (FIS) budget and funding to be transferred to other institutions which is of about 45 million euros; since 2000, the researchers of the ISCIH can no longer compete for this.

The strategies for adaptation based on external fund raising have varied among the centres that suffered the greatest reduction in transfers during the nineties, such as the CEDEX, the IGME, the ISCIH, and the CIEMAT. The ISCIH, the CEDEX and the IGME chose strategies that involved services to the Public Authorities, while the CIEMAT developed a strategy based on obtaining external funds and, fundamentally, through sales to the private-sector, cases where its R&D capabilities were almost a monopoly. In contrast, of the organisations receiving the most favourable treatment, at least during the worst years, the INTA is seen to be active in the search for external funding. Other PROs that have medium stress in terms of financial pressures, as it was the case with the CSIC, the IEO and the INIA have reacted with different intensity by means of getting external funding.

If the organisational and institutional conditions of all the centres were identical, a greater reduction in the budgetary allocation from the National Budget would be expected to

lead to a greater incentive for the organisations to search more closely for non-institutional funding sources. However, this correlation is neither linear nor direct; the percentage of external funding is variable among the PROs.

The degree of stagnation or reduction in the institutional funding, in constant terms, does not explain by itself the actions in place, nor it accounts for why some PROs have implemented and succeeded in obtaining external funding to an extraordinary degree in order to continue and even expand their R&D activities whilst others have not.

4 Differentiated adaptive reactions: “Autonomy” as an explanatory factor

The Spanish PROs had similar financial pressures, however, the proportion of external funding they obtained varies; some centres faced the problem using a strategy of **active adaptation**, others have **passively accepted** the new situation. In this section, we explore the factors that explain these variations.

We know that institutional trajectories explain much of the responses, but in this section we will explore other factors. We would argue that obtaining of external funding is the outcome of a complex process of interactions between the autonomy of the researchers with respect to their PRO, and the autonomy of the organisation with respect to the political system. The bases for the two types of autonomy are of institutional and organisational character.

The autonomy of an organisation with respect to the political system, which depends on the strength of the relationship with the tutelary Ministry, is what determines the room for manoeuvre for the management of the PROs. Autonomy in this sense means to move away from traditional missions, to become a general knowledge producer or a specialised supplier of knowledge for industry. The nature of the research work being carried out or the services offered by the PRO affect this type of autonomy, making it possible to establish contacts with the external research users and contractors, in different degrees according to the area of R&D, independently from the missions assigned by the Ministry.

A second factor, the autonomy of the researchers with respect to their organisations, is shaped by the way in which the research activity is organised, mainly by “semi-independent research groups” or through the “departments, units or institutes”. The impact of this factor is also mediated by the possibility for developing individual research strategies, based also on limited dependence on collective resources (infrastructures, equipment and human resources) which the organisation manages and, additionally, by the existence of automatic institutionalised individual economic incentives systems (not depending from the directors but

rather their obtention of funds) which weaken the traditional lines of authority in the organisation. The two types of autonomy are not necessarily linked.

4.1 POLITICAL AUTONOMY vis a vis THE POLITICAL SYSTEM

The Ministerial authorities maintain a relationship with the PROs which is shaped by the general regulations, the appointment of the directors and the allocation of annual institutional funding. On the other side, the PROs have a regulatory framework which allows them to obtain external funding which they can add to their budget in order to carry out research projects and activities.

The Ministries have a historical record of relationships with the PROs and some ministries have been “requiring” from them knowledge production, technical assessment or services which are necessary for carrying out their normal activities. If the tutelary Ministry promotes this type of relationship, it is difficult for the centre's director to refuse; what he/she can do is to request the necessary resources to carry out these missions so that the Ministry transfers greater resources by means of purchasing services, the signing of agreements or the commissioning of projects. Thus, Ministerial authorities must approve, permit and even promote the degree of autonomy of their affiliated centre to encourage the search for new funds that generally implies less dependence. The basis for this movement by the Ministerial decision-makers may be variable: the abandoning of the old idea of the centre's subordination exclusively to the needs of the Ministry, the acceptance of the new ideas for the co-ordination of the policies on science and technology, or simply the search for solutions to the limitations imposed by the budgetary restrictions; it could also be the result of the consolidation of a private sector able to provide the Ministry with the same services.

Then the PROs' escaping from the traditional mission of simple knowledge supplier to the Ministry is a precondition for the search of external funding. Without political autonomy of the PRO, neither managers nor researchers would have the conditions to be active in the search for external funds; if the mission is fully determined by the Ministry, managers and researchers tend to expect it should be supported by it.

Thus, our argument predicts that the lesser the degree of autonomy of the centres with respect to the political system, the fewer incentives there will be for the management of these centres to adapt to the new environmental pressures and to search for alternative funding. The PROs whose mission, due to their institutional history, is centred on the provision of technical assessment or services to their respective tutelary Ministry, will tend to pay less attention to the search of external funding, even in a crisis context. The management in these organisations does not see advantages in competing for resources, as these centres are not assessed by the increase

in their research quality or activity but rather by the degree to which they accomplish a delegated mission.

In contrast to this situation, those PROs with a general mission or technology transfer roles to some industries could find it advantageous and more feasible to increase their income from external sources. In these cases, the centres concentrate the greater part of their activities in research and may be characterised as knowledge producers. The opportunities for external funding are different and vary in each centre due to the existence of extensive R&D or focused programmes, contracts (military or industrial) or a technology demanding industrial sector.

The specific functional activity of the PRO creates certain situations which may affect their opportunities for adapting their funding strategies. In this case, our hypothesis predicts that the search for external funding would be more intense in those PRO which, due to their area of technology or research, are involved in specialised international R&D programmes or markets in which “to sell” their services and capabilities is a possibility. Finally, the differences in the nature of the research mission imply differences in terms of costs and financial requirements.

Thus, organisational autonomy, the first type of autonomy which we have analysed, is defined mainly by political dependence and by the outside opportunities available for financing the PROs' specific area of activity.

4.2 AUTONOMY OF RESEARCHERS: RESEARCH ACTIVITY, INCENTIVES AND RESOURCES

The second element in the explanation of the diversity of responses and funding strategies, the autonomy of researchers within the PROs, refers to the structure of individual incentives and capabilities for the search for external funding. Faced with the problems caused by the reduction in available internal funding, the greater or lesser degree to which diversification of sources is involved in the response depends firstly, on the way the research activity is organised, secondly, on the fact that professional career and salary prospects are associated with certain types of behaviours, and thirdly, on the extent to which the researchers accept the authority of the directors because they need the collective research resources managed by the PROs. In their search for external funding the research organisations face a problem of collective action. Organisations are coalitions of interest and managers need to mobilise those diverse interests towards organisational objectives. Authority of the managers is one of the possibilities, but institutionalised incentives, either moral or economic, could also be the necessary mechanism to solve the collective action problem; then once the precondition (the political autonomy of the PROs) is given, the search for external funding could be developed either from the authority of the PRO management or from the individual research groups.

Since Merton, it is agreed that the scientific ethos may encourage the researcher to do the best he/she is capable. Nevertheless, analyses of the systems of individual incentives and the

remuneration systems help to understand better the commitment of the scientists to the search for external funding. A researcher's income and his career are essential determinants of his results in research (Konrad and Pfeffer, 1990). If PROs need to increase their external funding, economic incentives would encourage their researchers, complementing their commitment to research; in that way individual interests become aligned with those of the organisation as a whole.

Certain economic or professional advantages must exist under the new financial conditions in order for researchers to compete for external resources on an individual basis. If competing for resources and search for external funding only means an increase organisational funds, the researchers will have little incentive to make any great effort in this direction unless the dependence on common resources is significant. In this context, the commitment which resolves the problem of collective action is strengthened by the research ethos, by setting up specific, individual economic incentives and by limiting the dependence of the individual researcher on the organisation's resources.

Organisations with greatest interest in obtaining external funding will offer economic incentives and professional advantages to their researchers. If the incentives encourage the researchers to compete for national, regional or European funds and for contracts with firms, the result will be an increase in the level of external funding for those PROs. This represents a type of active adaptation consequent to the aggregation of individual behaviours.

However, it may also occur that, due to its particular nature, the research activity of a specific centre requires a volume and type of resources and equipment which exceed the fund raising capacity of any individual researcher. In these cases, and only when that the organisation has a degree of political autonomy of the first type and access to non-ministerial contractor markets, we may find an increase in the external funding due, fundamentally, to managerial action. In these circumstances, the management of the centre interested in obtaining external funding may make a strategic use of the dependence of the individual researchers in order to align their interests with those of the organisation.

5 Funding strategies and diversity of responses

Following these dimensions we could elaborate a typology of PRO responses to the environmental changes:

?? Both a lack of organisational and individual autonomy, mean a situation of great dependence on the political system, and lead to a model of “**passive compliance response**” based on the more or less uncontested acceptance of the environmental changes and the

expectation that the tutelary Ministry or the Public Authorities will provide the solution to the problems which the centre is experiencing.

?? An increase in autonomy with respect to their ministries, based on a strategy of escaping from dependence, will be an **active response**. Furthermore the way in which research activity is organised and the power of the management are two internal organisational factors that condition the response.

- Systems where researchers have limited autonomy within the organisation, could produce a response that is the result of **managerial strategies** and actions; management control of collective resources in the organisation strengthens its position of authority. The response is active but, in this case organisational, as the search for external funding becomes a managerial function.
- Systems organised on the basis of “independent research groups” or with developed systems of individual incentives, which promote the autonomy of the researchers with respect to the organisation, or where investigators do not depend on the organisation's resources in order to carry out their research, could lead to a response to changes in the environment which would be also active, but based on **individual researchers' strategies**.

In fact having much more external income is, sometimes, the product of the sum of multiple initiatives by individual researchers whilst, on other occasions, it is the result of the institutional action of the centre's management or of the requests from the Ministries which exploit the abilities of their research centres.

Having now described the principal factors which explain the diversity in responses of the centres in their funding strategies we shall apply this typology to our cases. As it mentioned, the combination of the two dimensions gives us three different empirical types of strategies. The specific features of the PROs associated to the two dimensions of the autonomy allow us to situate them in the typology and to define the type of reactions that the PROs have developed in the last years as response to the crisis on the institutional funding.

Table 4. – Typology of the adaptive response strategies of PROs to the environmental changes. Percentage of external funding in brackets

<i>LEVEL OF AUTONOMY OF THE RESEARCHERS</i>	<i>HIGH</i>	<i>No Cases</i>	<i>Active responses (individual)</i> <i>CSIC (31%)</i> <i>INIA (18%)</i> <i>IEO (14%)</i>
	<i>LOW</i>	<i>IGME (8%)</i> <i>ISCIII (7%)</i> <i>CEDEX (6%)</i>	<i>CIEMAT (25%)</i> <i>INTA (20%)</i>
		<i>Compliance:</i> <i>Passive or conformist adaptation</i>	<i>Active responses (collective or managerial lead)</i>
		<i>LOW</i>	<i>HIGH</i>
		<i>DEGREE OF POLITICAL AUTONOMY OF PROs</i>	

Table 4 summarises the adaptive strategies and the level of external funding in the selected cases together with the relationship with the two forms of autonomy. The combination of these two dimensions of autonomy provides us with predictive elements on the state of the dependent variable. From this starting point, the levels of external funding may fall as the political autonomy of the centre with respect to their Ministries rises, when institutional funding guarantees were lost, up to the time when alternative “markets” for funding are found. A centre undergoing change may need some time for developing the “new practices” required to attract the external resources, i.e. consolidate a centre based on researchers who compete for research funds. The transition may occur more rapidly if external markets already exist which require research and knowledge in these areas.

Which centres have reacted and which have adapted to the environmental changes in the nineties and why? The centres which have shown greatest reaction in their funding strategies and, in consequence, showed the highest levels of external funding are: CSIC, CIEMAT, INTA and INIA. While those which showed more compliance were ISCIII, CEDEX and IGME. The following discussion details our arguments:

a) Active Reaction 1: Strategy of escaping from “dependence” based on “independent research groups”

The CSIC is the organisation which obtains a greater proportion of external funds. The CSIC represents the active type of strategy; and this is consistent with our argument as the CSIC is a centre which produces knowledge and which is involved in basic and applied research. It has markets, users and funders for their research activities. The CSIC also has an

institutionalised incentive system based on individual economic bonuses which have had a positive effect on the level of external funding during the nineties¹⁵.

With respect to career prospects, the CSIC is the only organisation with similar career prospects to that of the universities. Another non-material incentive for the CSIC researchers which encourages them to compete for external funding is their autonomy in project decision-making. The researchers who have external funds for their research projects and activities are free to decide in what they work. Furthermore, the acquisition of external funds creates a reputation for the researcher which works as an additional non-material incentive to compete for resources.

Thus, the CSIC is a case of an active adaptive response, made possible by its political autonomy and which is basically the result of the aggregation of the individual behaviours of the researchers who respond to the incentives and who do not depend to an excessive degree on the common organisational resources in order to carry out their activities.

The INIA and the IEO due to their structural features show a similar type of strategy though with considerably more modest results in terms of our dependent variable. Researchers do not depend too much on the common resources, but the absence of automatic individualised systems of salary incentives means that the response is smaller. In the INIA, the established system for the application of economic bonuses (productivity) -within the limits of traditional civil service- was also based on the assessment of the researcher's results; this could explain the higher external funding of INIA, in addition to the fact that IEO has lower financial stress and IEO researchers have more dependence on the organisational resources.

b) Active Reaction 2: Strategy of escaping from “dependence” based on “managerial authority”

A second type of strategy is illustrated by a group of centres which receives significant external funding and includes the CIEMAT and the INTA. These centres demonstrate a type of active adaptive strategy though this is led by management. They may also be considered as knowledge producers, but their specific mission is to carry out R&D in their respective areas:

¹⁵ Although the Science Act, in article 18.2, makes a general allowance for the generation of credit to compensate the productivity of civil servant researchers, the CSIC is the only one of the PROs which has developed this possibility to enable each investigator to receive a fixed percentage (30%) of the research carried out with the external funding from contracts or research projects financed within the EU R&D Framework Programme. It is also the only organisation which, like the universities, has “extraordinary productivity bonuses”(*sexenios*) which are added to the researchers salary when he or she successfully passes an evaluation of his/her research activities; this is offered for every six years of results and is cumulative over time.

energy and aeronautics and space. Their activities are centred on basic research and technological development.

The areas of research in which they are involved require high levels of investment and funding. This makes it difficult for individual researchers to initiate adaptive responses since they depend on the common organisational resources which are “controlled” by the management. This means that it is the management of these PROs whom is interested in obtaining external funds for research activities. However, none of these organisations have schemes for automatic non discretionary individual economic bonuses, as was the case in the CSIC; additionally the career perspectives for the researchers depend exclusively on their upward mobility to a position which is more beneficial in terms of retributions.

These centres illustrate a type of collective active adaptation not based on individual incentives, facilitated by a degree of freedom with respect to their Ministries which apply only moderate political pressure on the centres, allowing them to “sell” their research results in broader markets. The nature of the areas of research may also help to explain the level of external funding. Both centres are involved in highly internationalised areas of R&D, they occupy positions of monopoly with respect to the provision of knowledge in Spain, and require investment in technologically-advanced infrastructures. They also have powerful mechanisms to obtain external funds by involving themselves in European or international R&D programmes and through agreements with companies which may wish to invest.

c) Passive response: Compliance with the environmental changes

The third block is made up of those centres which have followed a more passive strategy in response to changes in the environment. Overall three cases (CEDEX, ISCIII and IGME) have not escaped from their ministerial political dependence and show lower levels of external funding. They are essentially service providers for their Ministries; for CEDEX, research is only a small part of its global activity. Thus, despite new opportunities to obtain funding, the management of these organisations has no clear incentive to do so. None of them have access to alternative "external markets" in which to sell their services. Furthermore, in these centres, there are no systems for compensation or professional advancement beyond the traditional schemes of the civil service. These are cases of passive adaptation to the changes in the economic environment caused by the absence, in practice, of the two types of autonomy which we have analysed.

In fact, the functional, institutional and legal arrangements affecting the Carlos III Health Institute and even its mission, are derived from the General Act on Health (14/86) and not from the Science Act. Also in the area of health, there is a great degree of slack in the organisations with respect to research resources, meaning that the pressure to obtain resources for research is perhaps lower. The centre is also a health service provider for its Ministry. We

could say that the three compliance centres have not escaped from the ministerial political dependence.

6 Final remarks

The aim of this work has been to explore the process of organisational adaptation of the PROs to the changes in their environment, using an analytical framework which combines the organisation theory with some elements of an institutional perspective. The actors in the public research organisations, both managers and researchers, have adapted to an economic environment of reductions in direct funding during the nineties and to changes in the political and legal environment which encouraged them to align their research with social and economic objectives, and which made the search for external funding more feasible. We have found a significant variation in the responses to this new economic environment, both in the type of strategy and in the intensity of the reaction, despite the changes in regulations had contributed to the building up of an “organisational field” from which a certain degree of isomorphism could have been expected. In contrast, the adaptation by the management and the researchers in the different centres was carried out selecting a particular type of behaviour from the different possible lines of action.

After investigating the diversity of these responses, measured as the percentage of external funding, we have hypothesised that the fundamental explanatory factor has been the degree of autonomy, made up on the one hand by the political independence of the organisations and, on the other, by the independence of the researchers within their centres. Both dimensions of autonomy have fundamentally institutional and normative bases; political autonomy comes from the historical relationship of exchange between the public research centre and its Ministries, it is a function of its mission, due to the room for manoeuvre implied by the hierarchical authority, and it is derived from possibilities of establishing commercial links with other actors in the system; individual independence is determined by relative presence in the organisations of individual incentive systems and of regulations on the use of common organisational resources which make the researchers more or less dependent.

The combination of different degrees of these two dimensions has provided us with a typology of adaptive responses in which we have located our cases, confirming that the relationship between our variables is not linear. The ability to develop strategies based on competitive fund raising, both public and private, requires a change of context and the relative abandoning of the functions of service provider to Ministries in exchange of regular institutional funding. From this point of view, this past pattern must be considered as a step in an ongoing process. Nevertheless, lack of political autonomy could be thought of as a stable pattern in

which all necessary organisational activities are supported by direct transfers. This scenario, however, appears to have disappeared definitively.

Further research is needed to study the direct impact on public R&D centres of new research actors and, finally, the changes in the public research organisations must be compared with the changes and transformations taking place in the universities as part of the research system.

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