The origin of public research organisation patents: an economic approach

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Abstract

While some studies on patenting by public research organisations (PROs) and universities altogether tend to be positive and descriptive, normative concerns have risen mainly on the side of university patenting. The specific dynamics of PROs, e.g. on the growth of their personnel and the creation of research units, allow them to make strategic considerations which are less present in universities but which may have an impact on patenting. However, PROs are often subject to similar requirements and legal frameworks to increase patenting, so the question of which factors have a determining influence becomes relevant. Without aiming to build a typology, we focus on large PROs that face singular decisions on the priority of scientific areas, decentralisation to regions and joint management of their research units and we take the Spanish National Research Council (CSIC), the largest PRO in Spain, as a case study. We also apply the production function approach typical in the case of universities to the context of PROs. The data consists of 2 794 patents applied for by the CSIC which we break down among an average of 95 CSIC research units per year over 19 years (1987-2005), thus creating a database of 1 812 observations. We learn that (i) the application of problems and methodologies from universities to PROs is fruitful to formulate/refine hypotheses on patent origination; (ii) according to the example of CSIC, returns to scale in the production of patents may be higher for PROs than for universities; (iii) there may be contradictory logics when PROs try to maximise their objective of producing patents.

Introduction

Patenting by public research centres (PRCs) has been the focus of some research because of some positive and normative concerns¹. Positive concerns deal with how to promote better commercial application of patentable inventions at PRCs, e.g. in Nordic

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European countries (Jacob et al., 2003) or point to the evidence that PRCs are only marginally engaged in patenting, e.g. in Southern European countries (Cesaroni and Piccaluga, 2005). These views tend to refer to universities and public research organisations (PROs)². More normative concerns deal with the possibility that this increasing trend of patenting at PRCs could have unforeseen consequences for academic research and technology transfer. Such analyses have mainly related to universities and, somewhat surprisingly, skipped the other main scientific producer, i.e. PROs.

Of course, universities are different from PROs and their dynamics may vary, e.g. universities have also a teaching mission and their growth depends above all on teaching needs while PROs tend to grow according to research needs. However, both universities and PROs tend to be subject to a similar legal framework on intellectual property rights, e.g. who owns the invention – the institution or the inventor, how they share potential income from the license of a patent, etc. Therefore, the significance of the normative debates for policy-making in the case of PROs is just as important, since similar justifications for changes leading to patenting at PROs may apply in the same way as at universities: a natural consequence of shifting patterns of research and an attempt to attract attention from industry and society. Actually, the involvement of most European universities into patenting is relatively recent and the trend towards increased protection of research results may have some margin before unexpected outcomes take place, whereas some PROs have a long-standing tradition of patenting and the same trend may be counterproductive in a shorter run.

From an economic perspective, a useful methodological approach to deal with the generation of patents by PRCs is the patent production function. It considers the number of patents as a function of some economic and contextual factors the influence of which we can determine through an econometric estimation. However, in parallel with the lack of normative debates at PRO, application has been principally on universities rather than PRO (Foltz et al, 2001; Payne and Siow, 2003; Coupé, 2003; Azagra et al., 2003, 2006, 2007; Calderini et al., 2005; Sapsalis et al., 2006).

This contribution will try to fill the existing gaps by analysing the origin of patents generated by PROs from an economic perspective and thus by applying the normative debates on university patenting and the patent production function approach to the context of PROs.

PROs are not homogenous, though. Although building a typology is out of the scope of this study, let us present some – tentative – criteria for a distinction among some – arguable – examples. In many countries, there tends to be a largest PRO with a horizontal coverage of many scientific areas (e.g. CNR, CNRS, CSIC, Fraunhofer Society, Max Planck Society, TNO, VTT...) and some smaller ones specialised in a few scientific areas. Among the largest ones, in some countries they tend to be mainly research performers (e.g. CNRS, CSIC, Fraunhofer Society, Max Planck Society, VTT) while in some others they also fund research (e.g. CNR, TNO). Even among research performers, some have been traditionally project-based research institutions (e.g. CNRS, CSIC, Max Planck Society) and some others contract research institutions (Fraunhofer Society, VTT). As a starting point, we claim that the analysis of large PROs, mainly research performers and traditionally project-based institutions is especially interesting. The reasons are that (i) they face singular choices regarding priority of scientific areas, decentralisation to regions and joint management of their research units – also a difference with universities, (ii) their focus on research performance may produce more patents, (iii) they have experienced changes in demand and financial constraints that have led them to rely more on contract research. The next

section, ‘Influences on patenting’ addresses these issues in some more detail. Then, we will take Spain’s CSIC as an example of the kind of PRO we are more interested in.

Since PROs may encompass several research units, the study will also provide some insights into the economics of science using institutions rather than individuals as a unit of observation.

Influences on patenting

The econometric literature on the determinants of university patent production has found it significant the effect of some economic factors (number of researchers, R&D expenditure) and contextual factors (scientific areas, regions, legal and institutional changes). Concerning the economic factors, we revise the literature on university patents and on the broader field of PRO production that can lead us to hypothesise similar links in the case of PRO patents. We discuss also some ideas from the economics of science that can lead to new hypothesis (e.g. on technological cooperation) or the refinement of existing ones (e.g. on types rather than on amount of R&D expenditure or number of researchers and partners). Concerning the contextual factors, we distinguish contextual factors that may involve decisions on the creation or management of research units (a specificity of large, horizontally specialised PROs compared to universities and small, vertically specialised PROs) and those that affect all research units at the same time (e.g. the legal and institutional framework).³

Economic factors: Human and financial capital

PROs consist of heterogeneous research units that vary according to the type of scientific production, structure of funding or homogeneity of research topics (Joly and Mangematin, 1996). Their size also matters, at least for policy-making. Bonaccorsi and Daraio (2005) show that in Italy the number of CNR research units drastically decreased between 1999 and 2001, with the smallest ones being abandoned in the belief that larger ones were more productive. Although there are theoretical bases to support that idea, the authors find some evidence that the opposite holds true – using data from 1997. What, then, is the effect of size on PRO patents?

Hypothesis 1. The greater the size of the PROs, the more likely it is that PROs will generate patents.

Let us consider the number of staff as a measure of input labour and size. Another source of labour apart from internal staff is cooperation with external partners. Lee and Bozeman (2005) discussed and tested the issue of scientific cooperation in an econometric setting with regard to its effect on academic publication production. They assumed that the number of co-authors in a paper reflected that some cooperation had taken place in the past and resulted into a later publication. The research question makes sense since in a knowledge-based society, researchers need to search out scattered pieces of information for one another and cooperate in order to expand the frontiers of understanding. Regarding patents, although networks of academic inventors have been studied (Balconi et al., 2004), the impact of this cooperation on patents owned by the public science system remains largely unexplored. An exception is the work by Sapsalis et al. (2006), who used the number of co-assignees as a proxy of cooperation and found

it positively associated to patent value (measured through forward patent citations). The impact was strong in the case of public co-assignees and weak or none in the case of private co-assignees. The authors did not estimate the impact on patent production or in the context of PRO. Therefore, our target question is whether cooperation between PROs and other partners fosters patenting and, if so, which kind of partners they are.

Hypothesis 2. The higher the amount of technological cooperation between PROs and selected partners, the more likely it is that PROs will generate patents.

One issue not tackled in the analysis of public patents is that the composition of staff may be also influential from a generation viewpoint. Bonaccorsi and Daraio (2003) find that the age structure has a negative effect on scientific productivity, i.e. research units with younger people are more productive. This raises the concern that the current trend in most European countries of ageing research personnel may be prejudicial. In countries like Spain this is caused by paralysation of the creation of tenured positions, something that keeps younger scientists out of PROs. However, temporary contracts may be seen as positive in increasing flexibility and reducing mismatches with new stakeholders' needs (OECD, 2003: p. 34). Other concerns are whether university professors in joint research units are as productive as their scientist colleagues with no teaching duties (Carayol and Matt, 2004), or to what extent more management resources in terms of administrative staff are useful. Are the current trends of entrenchment of research personnel in permanent positions and the switch to university personnel conducive to patents?

Hypothesis 3. Structure of staff matters: the composition of PROs according to their status, temporality and affiliation will influence the generation of patents.

Regarding financial capital, the growth of project vs. institutional public funding is widespread among most countries (OECD, 2003: p. 27). In countries like Spain this has led to different responses according to the type of PRO (Sanz and Cruz, 2003). There has not been much discussion, though, on the different types of project funding with regard to the agency supplying the funds. Thus, whereas national projects have been the traditional way of obtaining funds, countries joining the European Union gained access to supranational projects; moreover, regional administrations developed their own S&T policies that increased the amount of local projects. The possible effects on PRO patents should not be forgotten.

Regarding contractual funding, the possibilities of industrial application in growing fields of science, combined with the requirements policy-makers impose on new stakeholders in terms of providing tangible results (OECD, 2003: p. 8), have induced some PROs to increase working under contract, especially universities and PROs that have not been traditionally contract research organisations (e.g. CNRS, CSIC, Max Planck Society). While this is one of the bases of conceptual models such as the Triple Helix (Etzkowitz and Leydesdorff, 2000), other authors would argue that this might jeopardise curiosity-driven research (Pavitt, 1998). Hence it is interesting to ask what effect the increase in different kinds of external funds has on PRO patents.

Hypothesis 4. Type of funding matters: the amount of PRO activities according to their institutional origin (national, international, regional) and competitive origin (project or contractual), will influence the generation of patents.

In an econometric setting, hypotheses 1, 2 and 4 will lead to the estimation of the elasticities of the economic factors. The sum of the elasticities will allow us to test the type of returns to scale in the production of PRO patents. If we take university patents as a benchmark, there is some evidence of decreasing or constant returns to scale when the university, the department or the laboratory is the unit of observation (Coupé, 2003; Azagra et al., 2003; Azagra, Carayol and Llerena, 2006) and increasing returns at a greater aggregation level – the region (Azagra, Yegros and Archontakis, 2006). Let us assume that the behaviour of research units within the PRO is more analogous to the sub-regional aggregation level to formulate the next hypothesis.

Contextual factors on selected research units: Priority of scientific areas, decentralisation to regions and joint management of institutions

Resources do not flow homogenously across scientific areas but are subject to evolving priorities over time. In particular, promising fields like new materials, ICT, biotechnology or nanotechnology, e.g. areas touching on several disciplines at the same time (OECD, 2003: p. 13), have been the main beneficiaries of allocation of funds and the creation of research centres. Some authors would argue that a common characteristic shared by all these disciplines is that the frontiers between basic and applied matters are blurring (Etzkowitz, 1998), so patents should be a natural outcome. We might therefore ask ourselves if the priority of scientific areas corresponds to higher patenting in these areas.⁴

Hypothesis 5. PROs will show higher propensity to patent in scientific areas where they are actively creating research units.

In Italy, Bonaccorsi and Daraio (2003) argue that policy-makers have followed a strategy of agglomeration of CNR research units in certain geographical areas. This may be a specific feature of their country, because in Spain the CSIC no longer sets up research units in the country's capital, Madrid, but does so in other regions in line with a deliberate strategy. In any case, the authors find no conclusive evidence that regional concentration affects scientific production, so we may wonder whether the same applies to a related trend – decentralisation: Does decentralisation of research units to regions contribute to further patenting?

Hypothesis 6. PROs will show higher propensity to patent in regions to where they are decentralising their research units.

The creation of research centres poses not only regional questions but also managerial issues that analysis of the organisation of science has not debated much. Growing specialisation needs may require the birth of different research centres, with the possible disadvantage of excessive fragmentation of their parent PRO. In some countries PROs are quite flexible in compensating for the disappearance of old centres, e.g. within Max Planck in Germany. In other countries, institutions are more persistent and once created are difficult to disband. PROs may think of managing them jointly to benefit from economies of scale (through the creation of what we will call here "service centres") composed of administrative personnel only, e.g. within the CNRS or CSIC. Given that patenting involves many administrative procedures, one might imagine that research units belonging to a service centre will be able to reduce administration costs and thus

patent more. To test this will be another of our target questions: Is the joint management of research units a good way of promoting patenting?

Hypothesis 7. PROs will show higher propensity to patent through research units that share a joint management through a service centre.

Contextual factors common to all research units: Personally and political party-driven legal and institutional changes

It is now common knowledge among European researchers in the field of public patents that the Bayh-Dole Act in the USA constituted a major legal change favouring patenting activities by public research centres. Its effects have been widely criticised as (i) not having that much of an impact, since they may have only assisted an already existing trend on the part of universities (Mowery and Sampat, 2001), or (ii) even as being prejudicial because they increased the number of lower-quality patents (Henderson et al., 1998), probably due to newcomers (Mowery and Ziedonis, 2002). Coupé (2003) found in an econometric setting that no significant increase in patents could be attributed to the impact of the Bayh-Dole Act.

Europe has no regulatory watershed equivalent to that Act, and some researchers argue whether the European Union's or other OECD countries' attempts along these lines make sense (Mowery and Sampat, 2003). On a much more modest scale, in their case study of a European entrepreneurial university, Azagra et al. (2003) showed that an internal legal change had no effect on patents. Other research has pointed out that most patents with academic inventors in Europe are not applied for by universities (Azagra, Llerena, Carayol, 2006) and that once we take it into account, the differences with university patenting in USA are not so big (Dosi et al., 2005). Moreover, both university-owned and invented patents produce similar economic results, so no additional legislation is needed to make university patenting more attractive in Europe (Crespi et al., 2006).

Although there have been no equivalent lines of research on the effects of the US Stevenson-Wydler Act oriented at PROs, let us assume a similar degree of scepticism about whether concrete legal changes are effective, with no definitive evidence that they are. However, we can still ask whether the political climate has a more subtle impact. Such influence in a PRO is based on at least two factors: the term of office of a particular PRO Head and that of the government. As far as we are aware, econometricians have not tested such a proposition yet. So we wonder: Are particular personal leadership styles or governments in power able to induce patenting by PROs?

Hypothesis 8. Over time, particular personal leadership styles of PROs Heads or governments in power make the number of university patents increase.

The context of the research: CSIC

As mentioned in the introduction, at without aiming to build a typology, the CNRS, the Max Planck Society and the Spanish National Research Council (CSIC) are European PROs with some elements in common. These three institutions manage

themselves their research budget and human resources. However, we can also find some differences: CSIC is smaller regarding the number of scientists and technical staff, the amount of research budget and other measures of size that might condition the absolute value of the scientific and technological output of each of them. With some exceptions, CSIC has been usually a project-based organisation, differing from other European PROs that have always been contract research organisations, e.g. Fraunhofer Society or VTT.

The Spanish R&D public system is mainly based in the contributions made by Universities and PROs belonging to the Ministry for Education and Science. CSIC is one of them, together with other five: CIEMAT (nuclear and environmental research), IGME (geology and mining), IEO (oceanography), INIA (agriculture and food) and IAC (astrophysics). Other Ministries, such as the Ministry of Health, have their own PROs that perform research in medical and health disciplines. Dependent of Ministry of Public Works there is CEDEX (materials, hydrology and civil engineering). CSIC is the largest public research body in Spain, being a multidisciplinary body that covers all fields of knowledge, from basic research to technological development.

The CSIC was created after the civil war in 1939 (by an act of the 24th of November). Six boards went to make up the structure of the CSIC, a situation that remained the same until 1977: two dedicated to humanities and social sciences, two to animal and plant biology, one to inorganic sciences and, finally, one dedicated to technical research (the board known as “Juan de la Cierva Codorniu” or PJC).

In 1958 the Scientific and Technical Research Advisory Board (CAICYT) was set up, a commission that went on to run the Spanish scientific and technological system. The change introduced by the CAICYT was to replace the creation of new centres and to act via projects and programmes set up directly by state bodies, thereby avoiding the delegation of policies to the centres. In 1971, the CAICYT became the link between the different public centres of applied research and technology and the Delegate Commission for Scientific Policy.

In 1977, a new internal restructuring was put into practice with the first democratic mechanisms, hitherto absent, as well as regulating relations between this institution and the Ministry of Education and Science. In 1984, another novelty was introduced in the internal life of the CSIC. A Royal Decree established the procedure for creating and running institutes and centres of the CSIC directly linked to national scientific and technological research programmes.

1986 is the year of the Act to Promote and Generally Coordinate Scientific and Technical Research, the so-called "Science Act". Although this act must also be placed in relation to Spain joining the European Economic Community, we must not forget that it was the result of the growing awareness of the importance of scientific research for Spain. The new design of organisation and control specified by this act not only aimed to be more effective, capable of managing the new funding, and at the same time capable of handling the start-up of initiatives such as the National Plan for Scientific Research and Technological Development in 1978, but this new act also sought to provide a response to the new situations arising as a result of the arrival of democracy: the new State of the Autonomies and the entrance of Spain into the European Economic Community.

This entrance also induced the Spanish legislation to become compatible with European legislation and include regulations that had already been assimilated by the other member states. In the case of patents, it had to include what had been approved at the Munich Convention of 1973 on European patents and the Luxembourg Convention of the 15th December 1975 regarding Community patents. The Patent Act (LP) of 1986

therefore regulated the patentability of inventions following European law. This regulation is valid for private and public institutions, without distinction between universities and PROs.

Nowadays, CSIC is organised into eight scientific and technical areas: Humanities & Social Sciences, Biology & Biomedicine, Natural Resources, Agriculture, Physics, Materials, Food, Chemistry. It has more than one hundred research units – 40 of them joint research units, mostly with universities – and nine service centres, i.e. an institution for the joint management of research units as explained in the section “Influences on patenting” before formulating Hypothesis 7.⁵ There are research units in 16 out of the 17 Spanish NUTS 2 regions, plus one in Rome, i.e. it has a wide regional implantation. CSIC has also ten regional offices and one office in Brussels.

CSIC principal funding comes from the state general budget. Other support, over thirty percent of the total, comes from other sources, with a growing proportion of industrial funding.

Methods

Patent data come from the CSIC's Technology Transfer Office (TTO) in the form of 2 794 patents applied for by the CSIC. We broke them down across an average of 95 CSIC research units per year over 19 years (1987-2005), giving a database of 1 812 observations. As far as we are aware, this forms one of the largest databases in Europe for studying public patents at institutional level.

We applied count data econometric models in order to assess the determinants of different types of CSIC patents.

Independent variables include those on cooperation patterns from the same TTO database: logarithm of number of co-applicants, by type (other CSIC research units⁶, other PROs, universities⁷, business firms and other institutions) and nationality (national and foreign). We adopt Lee and Bozeman's (2005) approach to the case of publications and Sapsalis et al. (2006) to the case of university patents to assume that the number of co-applicants in a patent reflects that some technological cooperation has taken place in the past and may result into a later patent. This implies that the notion of technological cooperation used here includes inventive activity as well as commercial knowledge (i.e. once the invention is ready, partners appear to provide financial support to the project and market expertise). Still, this measure has the limitation that research and technological cooperation may take other forms and we cannot capture them. CSIC research units may potentially be conducting some collaboration, but they may not be patenting.

A second database compiled from CSIC memories allows us to include other independent variables on the research units' characteristics. These are total staff (in logs) and their composition (proportion of CSIC civil servants, CSIC working staff⁸, university personnel and other staff – mainly temporary), per capita amount of financial activities (number of national projects, other projects, contracts, in logs, divided by the number of total employees), scientific area⁹, region¹⁰ and being part of a service centre, i.e. an institution for the joint management of research units as explained in the section “Influences on patenting” before formulating Hypothesis 7.

Since we are looking at research units, we have to detect the presence of outliers. There is one in the sample, the Institute of Chemical Technology (ITQ)¹¹, so we created a dummy variable to allow it to have a separate intercept.

Finally, we controlled for time differences in terms of the length of each term of office of the CSIC's Head under each political party forming the government. There were eight CSIC Heads and three political parties in power in Spain during the observation period.

In the independent variables, we are one period behind every year in relation to patent application, in order to prevent endogeneity. The exception is co-application, which we take in the same year of patent application. However, this should not be a problem, since co-application indicates that technological cooperation took place before the patent application.

Results

Descriptive analysis

According to Table 1, CSIC patent applications increased 32-fold between 1987 and 2005. The proportion of co-applicants rose 2-fold and the average number of co-

Table 1. CSIC patents and co-applicants

Year	# of patents	% of patents with at least one co-applicant	Average number of co-applicants per patent								
			All co-applicants	Other CSIC research units	Other national PROs	Foreign PROs	National universities	Foreign universities	National firms	Foreign firms	Other institutions
1987	9	22%	0.22	0.00	0.00	0.00	0.00	0.00	0.22	0.00	0.00
1988	19	11%	0.11	0.00	0.00	0.05	0.05	0.00	0.00	0.00	0.00
1989	45	22%	0.24	0.00	0.00	0.02	0.07	0.00	0.11	0.04	0.00
1990	62	37%	0.39	0.00	0.00	0.05	0.08	0.00	0.21	0.05	0.00
1991	54	41%	0.41	0.00	0.00	0.06	0.09	0.04	0.15	0.07	0.00
1992	44	45%	0.45	0.00	0.05	0.05	0.07	0.07	0.07	0.16	0.00
1993	68	41%	0.46	0.09	0.01	0.03	0.04	0.03	0.22	0.03	0.00
1994	65	45%	0.63	0.28	0.03	0.08	0.05	0.00	0.20	0.00	0.00
1995	57	49%	0.58	0.21	0.02	0.09	0.12	0.04	0.05	0.05	0.00
1996	102	53%	0.61	0.14	0.00	0.01	0.16	0.04	0.15	0.11	0.01
1997	142	46%	0.50	0.04	0.02	0.02	0.22	0.02	0.08	0.10	0.00
1998	190	54%	0.69	0.04	0.01	0.05	0.12	0.08	0.33	0.06	0.01
1999	243	28%	0.31	0.06	0.00	0.01	0.10	0.02	0.05	0.07	0.00
2000	238	41%	0.47	0.13	0.04	0.03	0.09	0.02	0.12	0.02	0.02
2001	250	28%	0.42	0.14	0.00	0.02	0.11	0.02	0.08	0.01	0.05
2002	342	38%	0.52	0.19	0.01	0.06	0.14	0.03	0.06	0.01	0.02
2003	316	38%	0.55	0.10	0.02	0.05	0.16	0.04	0.11	0.03	0.04
2004	251	44%	0.57	0.14	0.02	0.02	0.16	0.06	0.12	0.01	0.05
2005	296	45%	0.59	0.15	0.07	0.04	0.18	0.02	0.09	0.00	0.04

Source: CSIC's TTO

applicants rose 3-fold during the same period. The growth is even higher if we take 1988 as the base year,¹² although it concentrated from 1988 to 1998. Many co-applicants were other CSIC research units and national universities, and their average number per patent grew. Cooperation with national firms was also high but it fell. Cooperation with other national PROs and all types of foreign institutions is below the average. It has grown with other national PROs but not with the rest of institutions, in particular with foreign firms.

Table 2 shows that CSIC total staff in 2004 is twofold what it was in 1986. Whereas the proportion of civil servants was over half at the beginning of the period, it had fallen to one third by the end. Although from lower absolute values, the decline in CSIC working staff was similar. Compensation comes from two sources. The first is the growth in university personnel, which also reflects the emphasis on creating joint research units with universities. The second and more important source is the increase in other personnel, making up almost half of the total nowadays. This category covers researchers funded by institutions other than the CSIC, with a more or less stable relation with CSIC, and also grant holders whose continuity is not guaranteed, i.e. it covers the bulk of temporary links with the institution.

The last three columns of Table 2 show that all types of R&D activity increased over the observation period. The number of national projects grew as much as the number of contracts did (in both cases increasing 2.2-fold), so we cannot confirm neither the view that the CSIC substituted the former for the latter neither the opposite¹³. It should also be noted that the highest growth occurs among other projects (up 3.6-fold) consisting of international, European and regional measures. This means that project-based activities have diversified their sources of funding at the CSIC.

Table 2. CSIC human and financial resources

Year	Total staff	% of CSIC civil servants	% of CSIC working staff	% of university personnel	% of other personnel	National projects per capita	Other projects per capita	Contracts per capita
1986	6 270	56%	14%	6%	24%	0.08	0.04	0.05
1987	7 245	52%	13%	6%	29%	0.07	0.02	0.04
1988	7 957	48%	13%	6%	33%	0.08	0.04	0.04
1989	7 898	48%	13%	6%	33%	0.09	0.05	0.05
1990	7 862	49%	12%	7%	32%	0.10	0.05	0.05
1991	8 175	48%	12%	6%	34%	0.11	0.05	0.07
1992	8 742	46%	11%	6%	37%	0.11	0.07	0.10
1993	8 257	47%	12%	6%	35%	0.11	0.09	0.06
1994	8 433	47%	11%	6%	37%	0.14	0.10	0.09
1995	8 720	44%	10%	6%	39%	0.13	0.11	0.08
1996	9 654	41%	9%	7%	43%	0.13	0.13	0.10
1997	10 157	39%	8%	6%	47%	0.14	0.14	0.07
1998	10 398	38%	8%	6%	49%	0.14	0.15	0.08
1999	10 762	37%	10%	8%	45%	0.15	0.18	0.08
2000	11 500	36%	10%	8%	45%	0.15	0.17	0.09
2001	11 771	35%	13%	9%	44%	0.16	0.16	0.08
2002	11 707	35%	9%	9%	46%	0.16	0.15	0.11
2003	12 749	34%	8%	9%	49%	0.17	0.15	0.12
2004	12 989	33%	9%	10%	49%	0.17	0.15	0.11

Source: CSIC memories 1986-2004

The priority of some research areas was moderate but still present at the CSIC, if measured by the number of research units. In Table 3 we can see that in two areas, Biology & Biomedicine and Physics, the number of centres grew above the average. Humanities & Social Sciences and Food grew about the average. Natural Resources, Materials and Chemistry increased a bit less. Agriculture is the only area that declined.

Table 3. CSIC research units by scientific area

Year	Humanities & Social Sciences	Biology & Biomedicine	Natural Resources	Agriculture	Physics	Materials	Food	Chemistry
1986	14	10	14	13	13	7	4	9
1987	13	10	14	13	12	8	5	9
1988	14	12	16	14	12	8	5	9
1989	12	13	16	14	12	8	6	9
1990	13	12	16	14	13	7	6	10
1991	12	11	16	13	13	8	6	10
1992	12	11	16	11	12	8	6	11
1993	12	11	16	11	11	8	6	9
1994	13	12	16	11	10	8	6	10
1995	13	12	17	11	12	8	6	9
1996	14	13	17	11	15	8	6	11
1997	14	13	17	11	15	8	6	11
1998	14	15	17	11	15	8	6	11
1999	16	17	17	12	19	9	6	11
2000	17	18	17	12	19	9	6	11
2001	17	18	17	11	19	9	5	11
2002	17	18	17	9	19	9	5	11
2003	18	20	17	12	21	9	5	11
2004	18	20	16	12	21	8	5	11

Source: CSIC memories 1986-2004

The CSIC's decentralisation strategy can be seen in Table 4, where columns 2 and 3 show how the number of research units in the capital, Madrid, fluctuated around 38 and then stabilised by the end of the period, whereas for the remaining regions it steadily increased and finally went up 1.6-fold. In a similar fashion, as columns 4 and 5 show, while the number of research units that continue to be managed on their own has scarcely risen, the number of research units becoming part of a service centre grew almost four times.

Table 4. CSIC research units by region and integration into a service centre

Year	Madrid	Other regions	Single research units	Research units, part of a service centre
1986	39	45	78	6
1987	39	45	78	6
1988	40	50	84	6
1989	40	50	84	6
1990	39	52	85	6
1991	37	52	82	7
1992	36	51	80	7
1993	36	48	77	7
1994	35	51	76	10
1995	36	52	77	11
1996	37	58	78	17
1997	37	58	78	17
1998	37	60	78	19
1999	39	68	85	22
2000	39	70	87	22
2001	38	69	84	23
2002	38	67	82	23
2003	40	73	90	23
2004	39	72	88	23

Source: CSIC memories 1986-2004

The evolution of the CSIC under the term of office of its different Heads ('Presidencies') and the parties in government appears in Table 5, where we divided the number of months by twelve (the maximum of twelve months per year is equal to 1). Presidents Nos 1 to 4 are in office under Party 1 until 1995. In 1996, President No 4 continues for three months under Party 1, then Party 2 wins the elections and President No 4 stays four months longer, but then he resigns. President No 5 enters the CSIC for the remaining five months of 1996 under Party 2. Presidents Nos 5 to 7 hold office under this party until 2004. In 2004, Party 1 comes back to power after new elections, President No 7 resigns and President No 8 takes over. We should explain that the two dominant parties in the period, Party 1 and Party 2, have different political leanings: while Party 1 is more left-oriented, Party 2 is more right-oriented. Testing whether one has a greater impact than the other on the production of CSIC patents is a proxy to test whether ideological differences matter.

Table 5. Length of CSIC Presidencies by party in government

	Pres1_ Party1	Pres2_ Party1	Pres3_ Party1	Pres4_ Party1	Pres4_ Party2	Pres5_ Party2	Pres6_ Party2	Pres7_ Party2	Pres7_ Party1	Pres8_ Party1
1986	1.00									
1987	1.00									
1988	0.75	0.25								
1989		1.00								
1990		1.00								
1991		0.50	0.50							
1992			0.58	0.42						
1993				1.00						
1994				1.00						
1995				1.00						
1996				0.25	0.33	0.42				
1997						1.00				
1998						1.00				
1999						1.00				
2000						0.67	0.33			
2001							1.00			
2002							1.00			
2003							0.17	0.83		
2004								0.25	0.08	0.67

Source: own elaboration

Regression analysis

According to the econometric estimates in Table 6, we start by running a Poisson regression that shows significant results according to the Pearson test and a fit around 70%.

The overdispersion tests suggest that a negative binomial specification may suit better; when we run it, the log likelihood function improves and the results are still significant. However, the Vuong statistic provides evidence that a zero-inflated model will be more adequate, and so we present these results. The log likelihood function improves again, the significant α parameter supports the idea that overdispersion is actually present and the significant τ parameter reinforces the detection of an excess of zeros.

Following the zero-inflated negative binomial model, the higher the number of total staff, the more likely it is that CSIC research units generate patents.

The elasticity of the number of total staff is positive and significant, which provides evidence in favour of Hypothesis 1. Co-application with other national PROs and (either national or foreign) business firms has the largest, positive, effect on patent production. Having other CSIC research units, Spanish universities and foreign PROs as co-applicants also enhances patent production, but to a lesser extent.¹⁴ Co-application with foreign universities and other institutions does not significantly affect the production of CSIC patents. Overall, we find evidence to support Hypothesis 2.

Research units with a higher proportion of CSIC civil servants (42% on average) patent as much as those with a higher proportion of other personnel – the benchmark (38% on average). Research units with a higher proportion of CSIC working staff (10% on average) and university personnel (10% on average) patent significantly less than the former.¹⁵ No particular kind of per capita number of funding measures is conducive to more patents. To sum up, the estimations support Hypothesis 3 but not Hypothesis 4.

The economic factors with significant effects are therefore the number of total staff and of most types of collaborators. The sum of their coefficients is much larger than one, so the generation of CSIC patents presents increasing returns to scale.

It is important to control for differences across scientific areas, since some have a higher propensity to patent, and this is the ranking: Chemistry, Food and Materials patent more than average; Physics, Biology & Biomedicine and Agriculture represent the average; Natural Resources patent less than average. Note that this is not exactly the same ranking depicted by the crude numbers from Table 3. The reason is that after discounting the higher allocation of some inputs, e.g. number of staff and collaborators, the propensity to patent is not so high. Therefore, Hypothesis 5 finds only partial support in the case of CSIC.

Regional variation does not seem to affect patenting, with only one exception (Andalusia shows a higher propensity to apply for patents). Being part of a service centre is significantly positive for patenting. In other words, Hypothesis 6 does not hold while Hypothesis 7 holds.

ITQ is actually an outlier and we need to control its propensity to apply for patents in order to moderate the impact of other effects. The significant, positive sign we find indicates that it stands out from other research units.

Table 6. Determinants of the number of CSIC patents by research unit and year

Dependent variable	Number of CSIC patents
	Poisson Regression
Number of observations	1 812
Log likelihood function	-2 253.88
Prob[$\chi^2 > \text{value}$] =	0.00
Adjusted R ²	0.73
Overdispersion tests: $g = \mu(i)$	6.02
Overdispersion tests: $g = \mu(i)^2$	5.56
	Negative Binomial Regression
Log likelihood function	-1 867.73
Prob[$\chi^2 > \text{value}$] =	0.00
	Zero Altered Neg. Binomial Regression Model
Log likelihood function	-1 803.13
Vuong statistic	4.88
	Coefficient (t-ratio)
Constant	-2.68 (-9.31) **
Human capital	
Total staff	0.56 (10.25) **
Proportion of CSIC civil servants	0.22 (1.26)
Proportion of CSIC working staff	-1.27 (-3.79) **
Proportion of university personnel	-0.77 (-3.16) **
Technological cooperation with	
Other CSIC research units	0.4 (3.56) **
Other national PROs	0.73 (2.26) *
Foreign PROs	0.4 (2.36) **
National universities	0.47 (4.89) **
Foreign universities	0.39 (1.8)
National business firms	0.74 (7.87) **
Foreign business firms	0.65 (2.44) **
Other institutions	0.09 (0.16)
Financial capital	
National projects	0.05 (1.19)
Other projects	0.04 (1.63)
Contracts	0 (-0.05)
Scientific area	
Chemistry	0.61 (7.35) **
Food	0.57 (5.14) **
Materials	0.46 (5.49) **
Agriculture	0.1 (1.07)
Natural resources	-0.28 (-3.58) **
Region	
Andalusia	0.29 (2.48) **
Valencian Community	0.22 (1.47)
Madrid	0.14 (1.13)
Asturias	0.24 (0.84)
Catalonia	-0.01 (-0.08)
Galicia	-0.01 (-0.07)
Aragon	-0.02 (-0.15)
Murcia	-0.14 (-0.56)
Canary Islands	-0.19 (-0.77)
Service centre	0.4 (6.16) **
ITQ	2.73 (12.98) **
CSIC President Party in the government	
Pres1 Party1	-0.28 (-2.67) **
Pres2 Party1	0.03 (0.32)
Pres3 Party1	-0.13 (-0.74)
Pres4 Party2	0.07 (0.21)
Pres5 Party2	0.28 (3.53) **
Pres6 Party2	0.46 (5.04) **
Pres7 Party2	0.33 (2.75) **
Pres8 Party1	0.5 (3.46) **
α	0.51 (8.02) **
τ	-2.89 (-8.3) **

** Significant at 1%. * Significant at 5%

The effect of successive CSIC Presidencies allows us to distinguish between two sub-periods over the observation period: the propensity to patent at CSIC research units significantly increased from the fifth President onwards. Under President No 4 patents were the same regardless of whether Parties 1 or 2 were in government.¹⁶ Moreover, the increase in patents continued at the end of the period no matter whether Party 2 or 1 was in power. This leads us to think that changes of government did not have an influence. Thus, the evidence is supportive of Hypothesis 8 concerning the presidency of CSIC but not concerning the government in the power.

Conclusions and limitations

The above results imply that despite some evidence in favour of decreasing or constant returns to scale of size to patents at universities, there appears to be increasing return to scale at PROs like CSIC. This may be because departments or labs at universities or universities themselves grow due to teaching duties, which do not head to more research results like patents. PROs, though, tend to augment their size because of R&D requirements than may lead to a convenient accumulation of critical mass. However, the case of CSIC may be idiosyncratic because it is smaller than some European homologous PROs.

The findings also show that higher patenting by PROs such as the CSIC results from another increasing trend, namely that of technological cooperation, or at least cooperation indicated by patent co-application. If the latter is desirable, we should not regard patents by PROs as being prejudicial to academic production. However, policy-makers and PROs should be aware that some partners are more conducive to patent production than others – in order to check whether this is the outcome of a conscious strategy. On the one hand, cooperation has grown with other national PROs and this is advantageous for patents, but it has also grown within CSIC research units and national universities, which is less helpful. On the other hand, cooperation has decreased with national and foreign firms, which would be more advantageous for patents. We must keep in mind that our measure of technological cooperation does not necessarily imply inventive activity but maybe commercial knowledge. Actually, our ongoing work by suggests that CSIC sometimes contacts co-applicants to internationally extend the original national application (Romero and Azagra, 2007). In any case, our study would benefit from a metric of co-operation other than that expressed by the number of co-applicants from patent records, e.g., indicators on partnerships in research grants and contracts, which are not publicly accessible.

By contrast, the current entrenchment of research personnel in permanent positions and the growth in university personnel are not coherent with an emphasis on patenting. So either more permanent positions should be opened at PROs like the CSIC, or patents should be considered a less relevant indicator of performance at research units with a lower proportion of permanent staff. The tendency towards an increase in other – mainly temporary – personnel appears to be more conducive, which suggests that the injection of new ideas is helpful. Our future work should nevertheless refine the distinctions among categories.

On the other hand, the trend towards increased contractual versus granted funding is neither advantageous nor detrimental for patent production. Perhaps the smaller growth in cutting-edge, more costly R&D funded through grants and probably leading to more inventiveness cancels out the higher growth in problem-solving, less costly R&D funded through contracts and probably leading to higher levels of industrial application.

Of course, one limitation of the present work is that we did not have data on the value but on the amount of funding activities.

Regional decentralisation has not contributed to further patenting by CSIC research units, so we should look carefully at why the two phenomena are not complementary. In any case, the joint management of research units through service centres and other cultural changes promoted by the leadership style of the Heads of PROs such as the CSIC appear to be beneficial. Not so regarding government action, which seems not to have an impact, perhaps because the rhetoric common to left- and right-oriented parties does not encompass different measures on PRO patents. Ongoing research is providing a historical perspective in order to boost understanding of the institutional policies and scientific background that influence patenting initiatives (Azagra and Romero, 2006). A tentative explanation is that once the general IPR framework was set in 1986 (see section ‘The context of research’), the presidential style of CSIC assumed these cultural changes – so it could be seen as a reactive rather than an active initiative. On turn, the changes were solid enough as to be independent of later rotations of the political party in the government.

This study is part of a larger project on CSIC patents. Future research will also study patents held by CSIC inventors not applied for by the CSIC and it will analyse technology transfer through CSIC patents.

Acknowledgements

To Ignacio Fernández de Lucio and Emilio Muñoz, for supporting the research in the context of the CSIC’s CTI network and providing guidance and advice at every step. To José Luis de Miguel and Domingo Represa, for allowing us access to the CSIC’s TTO database. To the latter for assistance in the understanding of that database. To Marcos Palomo, for compiling the raw data of that database. To Clara Giner, for allowing us to access some CSIC files in electronic format. To M^a Elena Zárate, for compiling part of the CSIC memories database. To Estela Hernández, for being able to find some old CSIC memories. To two anonymous referees, for suggestions on how to improve the contents of the paper.

References

- Azagra-Caro, J. M. and A. Romero-de-Pablos 2006. Patenting at public research organisations: a historical-economic approach. *DIME-Universities Working Paper Series*, http://uil.dime-eu.org/views/uil_publications
- Azagra Caro, J. M., I. Fernández de Lucio and A. Gutiérrez Gracia 2003. University patents: output and input indicators... of what? *Research Evaluation*, **12** (1): 5-16.
- Azagra-Caro, J. M., A. Yegros-Yegros and F. Archontakis 2006. What do university patent routes indicate at regional level? *Scientometrics*, **66** (1): 219-230.
- Azagra-Caro, J. M., F. Archontakis and A. Yegros-Yegros 2007. In which regions do universities patent and publish more? *Scientometrics*, **70** (3): 251-266.
- Azagra-Caro, J. M., N. Carayol and P. Llerena 2006. Patent Production at a European Research University: Exploratory Evidence at the Laboratory Level. *Journal of Technology Transfer*, **31** (3): 257-268.

- Balconi, M., S. Breschi and F. Lissoni 2004. Networks of inventors and the role of academia: an exploration of Italian patent data. *Research Policy*, **33** (1), 127-145.
- Baldini, N., R. Grimaldi and M. Sobrero 2004. Institutional changes and the commercialization of academic knowledge: a study of Italian universities patenting activities between 1965 and 2002. *CRESCO Working Paper*, **11**.
- Bonaccorsi, A. and C. Daraio 2003. Age effects in scientific productivity: The case of the Italian National Research Council (CNR). *Scientometrics*, **58** (1): 49-90.
- Bonaccorsi, A. and C. Daraio 2005. Exploring size and agglomeration effects on public research productivity. *Scientometrics*, **63** (1): 87-120.
- Calderini, M., C. Franzoni and A. Vezzulli 2005. If star scientists do not patent: an event history analysis of scientific eminence and the decision to patent in the academic world. Università Bocconi, *CESPRI Working Paper*, **169**.
- Carayol, N. and M. Matt 2004. Does research organization influence academic production? Laboratory evidence from a large European university. *Research Policy*, **33**: 1081-1102.
- Cesaroni, F. and A. Piccaluga 2005. Universities and intellectual property rights in Southern European Countries. *Technology Analysis & Strategic Management*, **17** (4), 497-518.
- Coupé, T. 2003. Science is Golden: Academic R&D and University Patents. *Journal of Technology Transfer*, **28**, 31-46.
- Crespi, G. A., A. Geuna and B. Verspagen, 2006. University IPRs and Knowledge Transfer. Is the IPR ownership model more efficient? *SPRU Working Papers* **154**.
- Dosi, G., P. Llerena and M. S. Labini, 2005. Science-Technology-Industry Links and the "European Paradox": Some Notes on the Dynamics of Scientific and Technological Research in Europe". *LEM Papers Series* **2005/02**.
- Etzkowitz, H. 1998. The norms of entrepreneurial science: cognitive effects of the new university-industry linkages. *Research Policy*, **27**: 823-833.
- Etzkowitz, H. and L. Leydesdorff 2000. The dynamics of innovation: From National Systems and "Mode 2" to a Triple Helix of academic-industry-government relations. *Research Policy*, **26**: 109-123.
- Foltz, J., K. Kim and B. Barham 2001. A Dynamic Count Data Analysis of University Ag-Biotech Patents. *Food Marketing Policy Centre Research Report*, **56**.
- Henderson, R., A. B. Jaffe and M. Trajtenberg 1998. Universities as a Source of Commercial Technology: A Detailed Analysis of University Patenting, 1965-1988. *Review of Economics and Statistics*, **80** (1), 119-27.
- Jacob, M., M. Johansson, T. Hellström, E. Iversen, P. Kutinlahti, K. B. Munk, L. G. Knudsen and S. B. Wennerberg 2003. SMEs and the new role of academic research in four Nordic countries, <http://www.nordicinnovation.net/prosjekt.cfm?id=1-4415-171>
- Jaffe, A. B. 2000. The U.S. patent system in transition: policy innovation and the innovation process. *Research Policy*, **29**: 531-557.
- Joly, P. B. and V. Mangematin 1996. Profile for public laboratories, industrial partnership and organisation of R&D: the dynamic of industrial relationships in a large research organisation. *Research Policy*, **25**: 901-922.
- Lee, S. and B. Bozeman 2005. The impact of research collaboration on scientific productivity. *Social Studies of Science*, **35** (5), 673-702.
- Martin, B. 2003. The changing social contract for science and the evolution of the university. In *Science and Innovation*, eds. A. Geuna, A. J. Salter and W. E. Steinmueller. Cheltenham: Edward Elgar.

- Meyer, M. 2006. Measuring Science-Technology Interaction in the Knowledge-Driven Economy. *Scientometrics*, **66** (2): 425-439.
- Meyer-Krahmer, F. and U. Schmoch 1998. Science-based technologies: university-industry interactions in four fields. *Research Policy*, **27**: 835-51.
- Mowery, D. C. and A. A. Ziedonis 2002. Academic patent quality before and after the Bayh-Dole act in the United States. *Research Policy*, **31**: 399-418.
- Mowery, D. C. and B. N. Sampat 2001. University Patents and Patent Policy Debates in the USA, 1925-1980. *Industrial and Corporate Change*, **10** (3): 781-814.
- Mowery, D. C. and B. N. Sampat 2003. The Bayh-Dole Act of 1980 and University-Industry Technology Transfer: A Model for Other OECD Governments? Available at <http://www.hbs.edu/units/em/Pages/semseries/mowery.pdf>
- OECD 2003. *Governance of public research*. Paris: Organisation for Economic Cooperation and Development.
- Pavitt, K. 1998. Do patents reflect the useful research output of universities? *Research Evaluation* **7** (2): 105-11.
- Payne, A. A., A. Siow 2003. Does Federal Research Funding Increase University Research Output? *Advances in Economic Analysis & Policy*, **3** (1), Article 1.
- Romero-de-Pablos, A. and J. M. Azagra-Caro, J. M. 2007. Internationalisation of patents by Public Research Organisations from a historical and an economic perspective. *11th ISSI Conference*, Madrid, Spain, 25-27 June 2007.
- Sanz-Menéndez, L. and L. Cruz-Castro 2003. Coping with environmental pressures: public research organisations responses to funding crises. *Research Policy*, **32**: 1293-1308.
- Sapsalis, E., B. van Pottelsberghe de la Potterie and R. Navon 2006. Academic versus industry patenting: An in-depth analysis of what determines patent value. *Research Policy*, **35**: 1631-1645.
- Wallmark, J. T. 1997. Innovations and Patents at Universities: the Case of Chalmers University of Technology. *Technovation*, **17** (3), 127-39.

¹ We will deal with patents applied for by public research centres. For patents with university inventors applied for by other institutions, see Meyer-Krahmer and Schmoch (1998), Meyer (2006), Calderini et al. (2004) and Azagra, Carayol and Llerena (2006).

² Since the terminology used to refer to the different kinds of institution treated in this study is not standardised, we propose the following conventions: a) public research centres = universities + PROs; b) PROs consist of "research units" (e.g. institutes, centres, laboratories, departments, etc.)

³ This is not to say that there are no more internal determinants of university patenting. Foltz et al (2001) and Coupé (2003) include a measure of faculty quality (average wage). Foltz et al. (2001), Agrawal and Henderson (2002) and Baldini et al. (2004) include a measure of patenting experience.

⁴ At all events it is important to control for disciplinary variation since some of them may show different propensities to patent. In the case of universities, it is widely accepted that patents in the USA are a phenomenon of a number of disciplines, e.g. chemistry, drugs, biotechnology and ICT (Henderson et al., 1998, Jaffe, 2000). However, according to national idiosyncrasies (Pavitt, 1998), there might be some other leading disciplines in patenting, e.g. mechanical engineering in Germany (Meyer-Krahmer and Schmoch, 1998). For single universities, the distribution by patenting disciplines may not be homogenous (Wallmark, 1998, Azagra et al, 2003, 2006). On the other hand, there are disciplines such as social sciences and humanities that do not produce physical technologies and thus are not likely to apply for patents. Other disciplines have legal restrictions on patenting (e.g. mathematics or software).

⁵ Let us give two examples: 1) The Centre of Organic Chemistry "Lora Tamayo" is composed by the Institute of Polymer Science and Technology, the Institute of Industrial Fermentations,

the Institute of Medical Chemistry and the Institute of General Organic Chemistry. According to its webpage (<http://www.cenquior.csic.es/>), the objective of the centre is “to cover the needs on large instrumental equipment, library, technical services, management of the building and its installations”. 2) The Physic Technologies Centre “L. Torres Quevedo” is composed by the Institute of Acoustics, the Institute of Industrial Automatics and the Institute of Applied Physics. According to its web page (<http://www.cetef.csic.es/>), it was created to “gather the technological activity of the three institutes, coordinate their research and achieve the appropriate synergy and critical mass”.

⁶ In this case, they are not co-applicants, but co-inventors, because when CSIC research units apply for a patent, CSIC is the applicant, not the research unit itself.

⁷ According to Spanish law, patents applied for by joint centres have both the CSIC and universities as the assignees. We consider technological cooperation to have taken place only when CSIC research units apply for a patent together with a university of which they are not a part. Therefore, we checked one by one the cases of co-applications by the CSIC and universities and counted just those in the latter situation.

⁸ There are some differences between CSIC civil servants and working staff. CSIC civil servants hold a permanent position. This category is mainly constituted by researchers, technicians and research assistants. There are also some administrative staff. CSIC working staff hold either a permanent or a temporary position, regulated by general labour statutes. There is a predominance of computer experts, librarians, porters, farmers and cattle-raisers in experimental stations, etc.

⁹ We take Physics, Biology & Biomedicine and Humanities & Social Sciences as a benchmark.

¹⁰ At first we refer to the 17 Spanish NUTS 2 regions: Andalusia, Aragon, Asturias, Balearic Islands, Basque Country, Canary Islands, Cantabria, Castile-La Mancha, Castile-Leon, Catalonia, Extremadura, Galicia, Madrid, Murcia, Navarre, Rioja and Valencian Community. Taking into account that the CSIC has no research units in Rioja but one outside Spain, in Rome, we would still have 17 regions. However, research units in six regions do not have patents: Cantabria, Basque Country, Castile-La Mancha, Extremadura, Navarre and Rome, so it leaves us with 11 regions. We take Castile-Leon and Balearic Islands as a benchmark.

¹¹ ITQ holds 20% of all patent applications. The next research unit holds *just* 8%.

¹² Another way to see this is that in 69% of our observations, CSIC research units did not apply for a patent. When they applied, 63% did it in cooperation.

¹³ We believe that with the value rather than with the number of contracts this substitution effect would be captured, since it is observable for CSIC as a whole. However, data at research unit level is not publicly available. We also believe that even with the number of contracts the effect would have been more notorious before the period of observation.

¹⁴ At the 5% significance level, the coefficients of the three former categories are not different from 0.9; while the coefficients of the three latter categories are smaller than 0.9.

¹⁵ Carayol and Matt (2004) find that the combination of permanent and temporary researchers enhances patenting and so does the combination of full-time researchers and university professors – at least in their Class 4 labs. Our results lead us to agree with the former but not with the latter. More evidence on the negative trade-off between teaching and research is contained in Azagra, Yegros and Archontakis (2006), where one of us found that the presence of joint research centres was not enough for universities to patent more. It seems that mixing research with teaching has advantages and costs, and the outcome depends on the context (Martin, 2003).

¹⁶ Pres4_Party2 is the benchmark.