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INNOVATION CAPABILITES IN THE PRIVATE SECTOR: EVALUATING SUBSIDIES FOR HIRING S&T WORKERS IN SPAIN

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Innovation capabilities in the private sector: evaluating subsidies for hiring S&T workers in Spain

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Abstract

This paper evaluates the effectiveness of a public programme intended to improve innovation capabilities in the private sector by subsidizing the hiring of R&D personnel. Using information from the programme management database, we study factors associated with the duration of contracts and their transformation into open-ended contracts, a basic aim of the programme. We explore the characteristics of subsidies, individuals, entities and projects related to the eventual stabilization of the new R&D employees, when the subsidies had ended. The programme was found to strengthen R&D capacity in recipient firms —above all in technology centres— yet only about half of the subsidized short term contracts had been converted into permanent contracts by the end of their second year.

Keywords:

Programme evaluation; company R&D and innovation; S&T employment; innovation policy; Spain.

JEL classification: O31**,** O38, H43, H83, Z18

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1. Introduction

There is quite a strong consensus regarding the Spanish system of science and innovation. Experts agree that the low levels of private funding devoted to research and development (R&D), together with a lack of highly qualified staff, are the main obstacles to company competitiveness and the improvement of total factor productivity.[1]

In 2001, the share of business R&D in the total R&D expenditure was 48.9% in Spain, whereas for the EU-15 it was 54.7%, and 65.2% for the US. This constitutes 0.49% of GDP, in contrast to the average 1.20% of the European Union, far from the figures for the US (1.96%) or Japan (2.27%). In 2002, Spanish investment in R&D barely exceeded 175 euros per capita; the EU average was 384 euros, and countries like France and the UK spent over 500 euros per capita, while Germany spent over 650 euros, and US investment was over 1,000 euros per capita.[2] R&D employees in the business sector were also scarce in Spain in 2002, amounting to slightly over 24,000 full-time researchers, out of a total of over 56,000 R&D personnel. This represented 0.13% of the active population of Spain, as compared to the EU-15 average of 0.29%. Such a situation can be attributed to the productive structure of Spain (Martín González and Rodríguez Romero 1977, Lafuente Félez *et al*. 1985), the de-industrialization of its economy during the 1980s (Maravall 1987), the specialization of large companies in services and construction (Fariñas and Jaumandreu *eds*. 1999), the lack of technology transfers from the public research sector (COTEC 1999) and/or limited government support (COTEC 2000).

Then, as a result of government initiatives, public support for business R&D began to expand. In the year 2005, 13.5% of the funds for private R&D came from the Spanish government, in contrast to the average 7.1% for the EU-15 countries. Indeed, Spain was the OECD country with the highest percentage of business R&D financed by government. Moreover, fiscal incentives for R&D in Spain were the most generous on the international stage (OCDE 2008), although they were not widely used due to their complicated design.[3]

The core of government support for private R&D was aimed at fostering the development of short term R&D and innovation projects and some innovation in R&D policy instruments

[1]For example: OECD (1987), OECD (2007), EC (2011).
[2]Data from EUROSTAT and OECD (*Main Science and Technology Indicators*).
[3]See OECD (2013) for an international comparison of public funding for R&D (including direct support and tax incentives) to business (http://www.oecd.org/sti/rd-tax-stats.htm).

took place in the mid 1990s. The year 1997 saw the onset of IDE Action ("Incorporation of Doctors in Enterprises"), offering subsidies for companies hiring doctorate holders. In 2001, the new "Torres Quevedo Programme" (PTQ) scaled up and amplified subsidies to "facilitate the incorporation of PhDs and technicians to businesses and technology centres". Although the PTQ has been functioning ever since, there has been no evaluation of its effectiveness or impact, merely administrative follow-up.

The aim of this paper is to look closely at the Torres Quevedo Programme, to assess its effectiveness in fulfilling its stated objectives and explore certain factors associated with the permanence of subsidized R&D personnel beyond the period of government support. The study is mostly descriptive and focused on R&D and innovation capabilities intended to improve competitiveness. It is our hope that this analysis will provide useful insights for further policy interventions. We also aim to contribute to the literature on R&D programmes targeted at improving the innovation capacities of firms. This entails analysis of subsidised contracts extended beyond the initial year to a second or third year, as the signing of permanent contracts was a necessary condition for the extension of subsidies to a third year.

The next section presents some previous literature about subsidies to stimulate R&D, and expounds our methodological approach. Section three describes the context and background of the programme, characterising its objectives, beneficiaries and requirements. Section four sets out the distribution of the programme's funds. Section five presents a statistical analysis to identify the variables most closely related to the extension of funding for an additional year. This leads us to some discussion and policy considerations.

2. Literature review and methodological approach

There is abundant empirical literature, both international and national, concerning public support for business R&D and innovation. Some general surveys assess the effects of public subsidies on company R&D investment (Zuñiga-Vicente *et al*. 2014), while other reviews evaluate the effectiveness of fiscal incentives (Hall and Van Reenen 2000) and direct subsidies or grants (David *et al*. 2000).

In Spain, empirical studies have recently examined the effectiveness of tax incentives for R&D (Corchuelo 2006; Corchuelo and Martínez Ros 2008; Marra 2008) or the effects of direct support to firms' R&D projects (Busom 2000; González and Pazo 2010; González *et al*. 2005; Herrera 2008). The common objective is to determine the effect of substitution (*crowding out*) or the additionality of public aid in conjunction with private investment for R&D. Most studies find that there is no crowding out effect, and that there is some additionality (or *crowding in*) in public aid, although its magnitude varies depending on certain company attributes (Busom *et al*. 2010; González and Pazo 2010). The existence of divergent empirical results is usually attributed to methodological differences related to the unit of analysis (Zuñiga-Vicente *et al*. 2014). However, an overview of the literature reveals ambiguous net effects in terms of the additionality of public subsidies on the level of company-financed R&D, and many studies are not conclusive.

Analysing the effect of aid for R&D upon employment in the sector is less common. Some studies examine the effects of subsidies on salaries (e.g. Thomson and Jensen 2010), and others analyse the determinants of demand for PhDs (Garcia-Quevedo *et al*. 2012) or the programmes supporting firms which hire PhDs (Cruz-Castro and Sanz-Menéndez 2005). The analysis of public programmes designed for hiring researchers and R&D personnel by firms is not common in the international context.[4] There are, however, relevant theoretical arguments supporting the positive effects of such programmes, given the relationship between the quality of human resources and the level of innovation.

Cohen and Levinthal (1990) underlined the role of absorptive capacity. Since then, this concept (understood as the capacity of a business to acquire, appraise, assimilate and apply new knowledge) has become widely used in empirical studies. Mowery and Oxley (1995), with an emphasis on human capital and the level/type of employees´ qualifications, define it as the set of skills necessary to deal with the tacit component of external knowledge that is transferred to the firm, or that the firm acquires, and to modify such knowledge.

Quite recently, Borras and Edquist (2014) signal as the main deficiency to be addressed by innovation policies the imbalance between a firm's internal and external competences. Thus, one criterion for the design of innovation programmes directed at the private sector would be to secure levels of absorptive capacity to tap into sources of knowledge. In Spain, researchers report that when firms have access to personnel with complementary backgrounds (that is to

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[4] Some programmes similar to IDE action exist. For instance, Mexico has some state level programmes (http://www.concytey.yucatan.gob.mx/proyecto.php?id_proyecto=21) and Argentina has a national one (http://www.agencia.mincyt.gob.ar/frontend/agencia/post/120), probably modelled on Spain's programme. For a review of programmes supporting the employment of research personnel in European countries, see Cruz-Castro (2007).

say, knowledge embodied in researchers coming from the public sector), this proves to be a stimulus to exploit and apply new knowledge in general (Herrera *et al*. 2010).

Zahra and George (2002) introduced the dynamic dimension, distinguishing between a firm's potential and realized absorptive capacity. This analytical distinction is of particular interest for our focus on permanence. Most empirical studies emphasise the second of these dimensions (the relationship between a firm's capacity to absorb knowledge and its innovation outputs). The potential component of absorptive capacities has received much less attention, yet according to Zahra and George (2002) it affords greater strategic flexibility in the mid- to long term. The use of human resources for R&D is the central input mechanism for business processing and appraising external knowledge. By focusing on the hiring and permanence of R&D personnel in the firm, we address precisely this potential component. It is important to stress that the potential capacity to appraise and acquire knowledge does not ensure its exploitation, and therefore may not be interpreted as a difference in terms of results or outputs.

Aside from approaching the potential component of absorptive capacity, we underline the importance of private investment in R&D in terms of work contracts. It is our understanding that the greater the duration of the contract, the greater is the accumulation of human capital in terms of researchers and technicians hired. Lower turnover could be associated with better incentives for sustained company investment in R&D (Acemoglu and Pischke 1999).

Determining additionality and its impact on R&D has proven to be a relevant approach in the empirical literature (Buisseret *et al*. 1995; García-Quevedo 2004). In short, there is an alleged effect attributable to the aid. This concept is based on a counterfactual appraisal, which consists of evaluating a real situation (e.g. subsidy leading to employment) and a hypothetical one (no aid, no contract). To construct counterfactual situations, the most demanding methodology would entail designing a control group among firms not requesting aid, then comparing both groups (beneficiaries and non-requesting entities) with regard to some indicator of input, output, or behaviour (Cook and Campbell 1979; Georghiou 2002, 2004; Georghiou and Roessner 2000). Despite some causal attribution problems, this type of quasi-experimental methodology is popular and valuable for the evaluation of programmes aimed at estimating R&D input or output additionality.

Some previous research into R&D subsidies in Spain deserves mention here. Arqué-Castells (2013) analyses whether R&D subsidies can be used to generate permanent inducement effects in Spanish manufacturing firms even after the withdrawal of the subsidy; focusing on *sustained* inducement effects, he measures the importance of "true state dependence" and the probability of high R&D performance in subsequent periods of time. Interestingly, his findings show that the subsidies needed to generate permanent effects in SMEs (small and medium-sized enterprises) are larger than those needed to produce permanent results among large firms. Unlike most of the existing literature, he focuses on an input variable: R&D investment.

In the same vein, we consider the decision to retain newly hired science and technology (S&T) workers, in the last year of aid, which is also an input decision. We analyse the continuity in the firm of PhDs and technicians hired by means of a subsidy in order to determine the recipient characteristics that make the programme effective. The employee consolidation indicator is used to measure the fulfilment of the PTQ programme objectives.

It is important to acknowledge that our programme evaluation entails data availability constraints. Our data come from the administrative records of the programme itself. It does not allow us to compare recipients and non-recipients and monitor their performance following the years of support, so as to isolate the effects of the programme with respect to other confusing factors. However, we believe the source is useful to address research questions concerning the effectiveness of the programme and to uncover interesting information for subsequent policy interventions.

We analyse the duration of the subsidy as an indicator of integration of the PhD/technician in the firm, and of increased company capacity. In the absence of continuity, the S&T worker might have joined the ranks of the unemployed or another company. One important limitation of using administrative data in programme evaluation studies is that information tends to be limited to recipients, and restricted to the period where they benefited from policy support. Because our database suffers from these limitations, we were not able to explore alternative scenarios for mobile S&T workers.

3. The Torres Quevedo Programme (PTQ)

Spain's first initiative to directly support the hiring of S&T personnel exclusively directed to the private sector came through the "Action of Incorporation of Doctorate holders into Enterprises" (IDE), which ran from 1997 to 2001 (Sanz-Menéndez *et al*. 2004; Cruz-Castro and Sanz-Menéndez 2005a; COTEC 2006), when it was replaced by the Torres Quevedo

Progamme (PTQ). The IDE initiative was intended to support the hiring of recent PhDs having no previous relation with the firm in question, and it gave preference to small and medium enterprises (SMEs). Between 1997 and 2001, it provided subsidies for contracting 602 PhDs in 371 firms.

The main differences between IDE and PTQ lie in the broadened scope and objectives of the latter.[5] It extended the number of beneficiaries and profiles of the activities eligible for subsidies, and made wage negotiation more flexible. It also increased the administrative requirements as well as the general conditions for granting and processing the financial aid (establishment of guarantees, payment systems, etc.), all of which meant a greater complexity of the programme from the standpoint of end users or beneficiaries. Objectives also evolved. Whereas IDE was conceived to stimulate the demand for doctorate holders and to improve the innovative capacity of firms, PTQ aimed to sharpen the competitive and innovative edge of businesses through the employment of R&D personnel, and to strengthen the focus on the capabilities of firms rather than stimulate the demand for R&D personnel. PTQ also included the consolidation of recently created technology firms, and technology transfer was furthermore promoted through the mobility of personnel originally trained in public research centres. Thus, the programme had a broad potential target population and aimed to expand the base of innovators while increasing the efforts of regular R&D performers. The PTQ's first call for applications even mentioned promoting the return of PhDs and technicians from abroad, an issue to be addressed by another programme, known as "Ramon y Cajal" (Cruz-Castro and Sanz-Menéndez 2005b); the statement disappeared from the 2003 call. From the very beginning the renewal of temporary annual contracts was rewarded by an additional subsidy for a further year; later on, permanent contracts were explicitly promoted.

PTQ subsidized the temporary employment of technicians (with three-year degrees and one year of experience in R&D) and PhDs, regardless of the years of experience, in companies and technology centres, for the development of R&D and innovation projects or to reinforce existing lines of research. The evaluation of proposals considered the quality of the project and the CV of the candidate, the fit of the three elements, and the alleged impact that the hiring would have on the current R&D capacity of the organization to be benefited.

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[5] For a more detailed description of PTQ see Martínez *et al*. (2013).

The types of activity to be developed by these PhDs and technicians were determined by the needs of the marketplace. In 2001, subsidies were only granted to projects involving industrial research (as in IDE) and technical viability studies; after 2004, projects for technological development became eligible as well.

With respect to the eligible organizations, in 2001 only firms and technology centres were considered. In 2003 there was an explicit extension to spin-offs,[6] and in 2004, to business associations. Technicians could only be hired by SMEs (or by technology centres after 2002), while large firms and business associations could only hire PhDs.[7] Thus, in the long run, there was a tendency to increase the types of beneficiaries from the private sector.

The aid provided by PTQ was fixed as a percentage of the total cost of the annual contract, so that the annual cost for the beneficiary could not be less than 26,748 euros (including Social Security costs). PTQ grants lasted for one or two years, and extension for a third year could be requested, with the condition that the R&D worker became a permanent employee. Aid through the PTQ could also be adjusted, as it varied depending on the type of beneficiary, the contract, the project type and the location (region). PTQ determined the maximum level of the subsidies (Table 1).[8] These percentages increased by ten percentage points for the regions that were designated as less favoured EU "Objective 1", and five points for "Objective 2" regions (although this distinction disappeared in 2004).

Table 1. Maximum gross intensities of PTQ aid
(% of the total hiring cost in the case of a PhD or technician)

	Large firms, technology ntres, business associations	SMEs
Industrial research projects	50%	60%
Technical viability studies prior to industrial research activities	75%	75%
Technological development projects	25%	35%
Technical viability studies prior to technological development projects	50%	50%

Source: Order regulating the Torres Quevedo Programme 2004 (BOE 08-10-2004)

[6] Spin-offs are defined as new businesses founded by personnel from a public R&D institution, dedicated to developing and commercializing an invention.
[7] In later calls, after the years studied here, all types of firms were allowed to hire technicians.
[8] PTQ relies on appropriations from the Spanish General Budget as well as from structural funds from the EU. The European Social Fund was used to co-finance activities in the regions designated as Objectives 1 or 2 (in the period 2000-2006), under the limits set by the Community Framework for State Aid in Research and Development and Innovation.

The maximum quantity of the subsidy had a decreasing nature (Table 2). The amount of aid diminished over time after the first year; an additional requirement to extend the subsidy for a second or third year was that the annual gross salary of the hired individual be equal to or greater than that stipulated for the first year. Likewise, aid for a third year was granted only if the employer had by then formalized a permanent contract with the S&T employee.

Table 2. Maximum amounts for PTQ aid (in euros)

	First year	Second year	Third year
PhD:			
Region Objective 1	28,488	22,790	18,992
Region Objective 2	17,093	15,194	15,194
Technician:			
Region Objective 1	20,987	16,786	13,988
Region Objective 2	12,590	11,191	11,191

Source: Order regulating the Torres Quevedo Programme 2003 (BOE 15-04-2003)

The aid granted by PTQ was at first managed by means of an anticipated payment of the total subsidy at the time of awarding it and required a warrantor for that amount. Later on, as a result of the European Norms for the Management of Structural Funds and the greater control demanded by the Spanish Law for Subsidies (Law 38/2003), payment of the subsidies was made at the end of each year, after the actual expenditure. Even so, there was the possibility of requesting an advance payment (with guarantees provided by the beneficiary).

Lastly, the programme required the applicant to contact the interested individuals, or vice versa, directly or by means of an intermediary during the application process, although the candidate S&T worker was meant to have no previous labour relations with the beneficiary. The exclusion of hiring persons previously associated with the applicant was clearly meant to increase the number of S&T workers in the private sector and to avoid substitution effects.

4. PTQ subsidies approved

The analysis that follows focuses on the beneficiaries receiving subsidies between 2002 and 2008, as a result of their participation in the first five calls published in 2001-2004. Over the period analysed, 70% of the 1,777 contracts approved were for SMEs, which represented 59% of all the contracts approved for PhDs and 77% of all the contracts approved for technicians. Technology centres were granted 24% of all contracts (26% of those for PhDs and 23% for technicians). Large firms, which were not allowed at the time to contract technicians through the programme, were granted 14% of the contracts awarded to PhDs (Table 3).[9]

Table 3. Number of PTQ contracts approved
PTQ 2001-2004 calls

	PhDs	% total PhDs	**Technicians**	% total technicians	**Total**	% total
SMES	**429**	59%	**811**	77%	**1,240**	70%
Technology centres	**190**	26%	**238**	23%	**428**	24%
Large firms	**104**	14%			**104**	6%
Total	**728**	100%	**1,049**	100%	**1,777**	100%

Source: Authors' elaboration, using information from the database of administrative records, Torres Quevedo Programme, *Ministerio de Ciencia e Innovación*, 2010.

Altogether, 900 different beneficiary entities had at least one PTQ contract approved (Table 4), of which 742 were SMEs (82% of the total), with 1.67 approved contracts each, on average.

Table 4. Number of entities with PTQ contracts
PTQ 2001-2004 calls

	Entities	% Total Entities	Number of subsidies approved per entity			
			Mean	Standard Deviation	Minimum	Maximum
SMEs	**742**	82%	1.67	1.45	1	17
Technology centres	**87**	10%	4.92	5.60	1	34
Large Firms	**71**	8%	1.49	0.98	1	6
Total	**900**	100%				

Source: Authors' elaboration, using information from the database of administrative records, Torres Quevedo Programme, *Ministerio de Ciencia e Innovación*, 2010.

These entities are quite diverse and their distribution may not be fully representative of the whole population of institutions performing R&D in the private sector in Spain during the years of study. Large companies (over 250 employees) represented 11% of the population of Spanish firms carrying out R&D, but they employed 43% of total R&D personnel. The contrast between the reference population and the beneficiary entities is greater for large firms —PTQ approved contracts for just 71 large firms (1.49 subsidies each, on average), representing less than 8% of beneficiary entities. The number of large firms with successful

[9] Business associations were also eligible for PTQ subsidies from 2004 onwards, but are excluded from the analysis because they only received five subsidies for PhDs in the period of study.

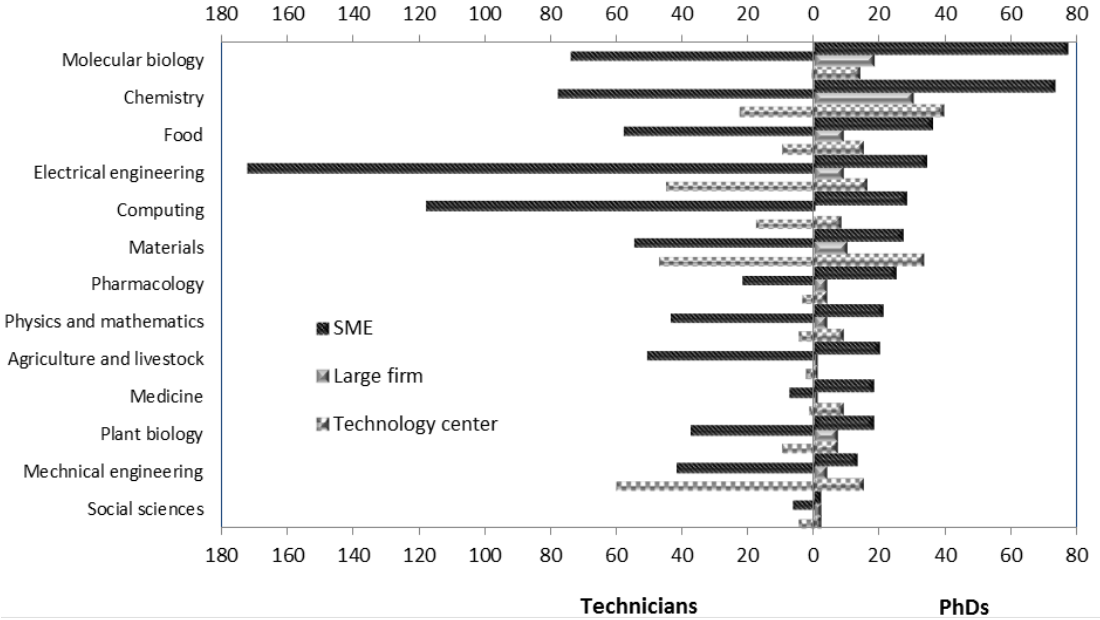
applications per call was initially quite modest but increased substantially over the period, from 5 in 2001 to 30 in 2004.

The programme was more frequently used by SMEs. The number of SMEs with successful applications experienced a substantial increase between the 2001 and 2004 calls, from 72 in 2001 to 417 in 2004. However, over 7,000 SMEs had R&D activity in Spain in 2003, according to the Spanish Statistical Office (INE).

Technology centres were the group benefiting most from the programme: 87 centres gained at least one contract, with an average of 4.92 subsidies each. Dispersion was considerable, with a standard deviation of 5.60, and in some cases extreme (e.g. 34 subsidies for one centre). These figures point to the relatively greater impact of the programme on technology centres, especially bearing in mind that there were only about 100 such centres in Spain at the time (Gracia and Segura 2003). There were 14 technology centres with contracts approved in 2001, and 46 in 2004.

Broken down by scientific and technological areas, PTQ-approved contracts for PhDs were concentrated above all on projects related to chemistry and molecular biology, the only areas with more than one hundred projects approved (Figure 1). In chemistry, 51% of the subsidies for PhDs went to SMEs; in the case of molecular biology, this figure was 71%. In general, SMEs were granted a majority of subsidies for PhDs, except in mechanical and material engineering, fields where technology centres came first. Large firms got over ten subsidies in two areas: chemistry with 21%, and molecular biology with 18% of all PhD aid. As for technicians, the area receiving most subsidies was electrical engineering, with over 200 contracts, 79% of them for SMEs, followed by computer science, with more than 130, 87% in SMEs.

Figure 1. PTQ contracts by scientific field
PTQ 2002-2004 calls



Note: Information on the projects' scientific fields is only available for 2002-2004, as it was not required in the first call.
Source: Authors' elaboration, using information from the database of administrative records, Torres Quevedo Programme, *Ministerio de Ciencia e Innovación*, 2010.

Not all the subsidies approved were effectively formalized into contracts and, amongst them, approximately half reached the third year.[10] Out of the 1,708 contracts receiving at least the first year of subsidy, only 878 were extended up to the maximum of three years, meaning that the persistence of the R&D employee in the same entity after the end of the subsidy was less than 52%. The programme allocated a total of 67 million euros in the first five calls published 2001-2004.[11]

In what follows we will focus on the contracts that received at least the first year of subsidy, to discern which factors are associated with the extension of support for one or two additional years.

[10] 69 applications of the 1,777 approved were withdrawn before the first yearly instalment was due.
[11] For further information about contracts approved and budget allocated per call see the Annex in Martínez *et al*. (2013).

5. Factors associated with the duration of PTQ contracts

PTQ subsidies could be assigned for a maximum of three years. Approval of the third (and final) yearly instalment was conditional on: i) a positive evaluation of the first two years; and ii) the conversion of the initial fixed-term employment contract into a permanent one by the end of the second year of the subsidy, to ensure that the worker would continue at the beneficiary entity beyond the third year of the PTQ subsidy.

We therefore hypothesize that receiving the third yearly subsidy of PTQ was associated with a higher probability of persistence of the employment relation and an increase in the innovation capacity of the recipient entity. Thus, the duration of the PTQ-subsidised contracts and the factors associated positively and negatively to such duration would be relevant for discussion about the design of programmes and policies aiming to raise S&T capabilities in the private sector.

We present a statistical analysis whose results should be interpreted as exploratory, pointing to significant associations between variables. Many intervening factors may influence the duration of the PTQ. Because our analysis is by no means exhaustive regarding factors that may affect contract duration, we interpret the results cautiously, refraining from inferring causal relations. Factors unobservable to us may be of a professional nature (integration of the person in the benefiting entity; competitiveness of the salary offered; opportunity costs of remaining in the firm if the person received other offers, etc.), a financial nature (the cost of hiring was not covered by the subsidy being too high for the recipient; the cost of establishment of guarantees if payment in advance was requested), or field-dependent (duration of R&D and innovation projects being greater in some disciplines than in others). As shall be seen below, we use information available from the administrative database of the programme regarding some basic characteristics of the beneficiaries and the projects, and include regional dummies in the regressions to control for unobserved regional heterogeneity (i.e. industrial structure, academic system, labour market, economic conditions, etc).

At this point, we limit our analysis to contracts that received subsidies between 2002 and 2008, and were approved in the calls 2002-2004, that received at least the first yearly instalment of the subsidy. The period chosen is important because during those early years, PTQ requirements affecting the variables of study were reasonably stable. This is important since we focus on a variable (duration of subsidized temporary contracts) that is very sensitive to the situation of the economy in general and the labour market in particular; in the years considered in the analysis Spain witnessed a moderate expansion of private employment in R&D.

Excluding all contracts lacking information on the variables of interest, we studied a total of 1,507 contracts (see Table A1 in the annex for the number of yearly subsidies awarded by type).[12] One in four of these contracts ended after one year (29% for SMEs, while for Technology centres the share was 16%). An additional 23% of the contracts were not renewed at the end of the second year. Thus only 52% of the initial set of employees continued in the beneficiary entity during the third year with an open-ended contract.

5.1. Empirical strategy

Given the ordinal character of the dependent variable —subsidized contracts lasting one, two or three years— we used an ordered logit model to estimate the effect of a number of factors on the duration of the support. Regressions were performed for three samples: all contracts, contracts for technicians only, and contracts for SMEs only. To test the robustness of results we also present results from applying generalized ordered logit models to the three samples (see supplementary tables). The generalized ordered logit does not impose the proportional odds assumption (Williams, 2006) and allows the relationship between the explanatory variables and the decision to renew another year some room for variation from one year to the next, which could be of importance for our analysis because the yearly instalment decreases over time.

Table A2 in the Annex presents the definitions of the variables available in the administrative database of the programme. These variables refer to the characteristics of the individuals benefiting from the subsidized contracts (PhD or technician, gender, number of years since first degree); the main features of the beneficiary entity where the contract is performed, such as type (SME, large firm or technology centre); and other features such as years since its creation, share of R&D staff and whether located in a less-favoured region (EU Objective 1). The latter is relevant because the quantity of aid allowed is higher for institutions from these regions, where a policy supporting S&T capabilities in the private sector is most needed. The

[12] We thus exclude 270 contracts from the initial sample of 1,777. They include 105 contracts approved in the 2001 call, because they do not have information about fields, 69 contracts from the 2002-2004 calls that were approved but did not obtain the first (e.g. the potential recipients withdrew their application before formalizing the contract) and 96 contracts from the 2002-2004 period for which some information was missing in some of the principal main variables of interest.

database also includes information about the scientific and technological areas of the projects carried out by the beneficiaries of the PTQ contracts. We grouped them into four broad areas: 1) engineering (mechanical engineering, electrical engineering); 2) chemistry (molecular biology, plant biology, medicine, chemistry); 3) computing; 4) other (physics and mathematics, social sciences, food, agriculture and livestock, materials)[13]. Financial features of the subsidized contracts include whether the recipient required advanced payment of the subsidy; the salary received by the subsidized employee, and the share of the total employment cost that was subsidised by the programme.

5.2. Descriptive statistics

In Table A3 of the Annex we present the mean values of the main variables organized by contract duration with reference to the full sample of contracts and four subsamples. Contract duration can be equal to one, two or three years, depending on the number of yearly instalments received by the beneficiary entity. Three-year contracts are those which were required to be converted into open-ended contracts after the second year. The four subsamples considered are: i) contracts for PhDs only; ii) contracts for technicians only; iii) contracts for SMEs only; and iv) contracts for technology centres only. The variation of contract characteristics for the different contract lengths appears to be significant only when considering all contracts, and for the groups of technicians and SMEs. The variables that present significantly different distributions with respect to contract duration are: the project fields, the types of entities, the proportion of R&D staff at the recipient entities, and the share of costs subsidized by the contract[14].

The share of cost subsidized by the contract —the only financial variable included in the regressions below— appears to be highly correlated with the location of the recipient institution (less-favoured region) and with the salary received by the worker. The share of R&D staff tends to be higher in technology centres and lower in large firms and SMEs.

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[13] Among the characteristics of the contracts with information available from the administrative database of the programme, some variables were observable only at the time of application for funding (characteristics of the person, entity and project), whereas the financial variables related to the subsidy changed from one year to the next.

[14] Correlations of variables for the full sample are available as supplementary material at the end of the document.

5.3. Regression results

Table 5 below presents the results from performing ordered logit regressions of contract duration (one, two or three years) on the full sample of contracts, as well as on the subsamples of contracts broken down by type of employee (technicians and PhDs) and by type of host entity (SMEs and technology centres).[15]

Estimations are presented in terms of odds ratios, and thus higher values of a given explanatory variable are associated with longer PTQ contracts when the corresponding odds ratio is above 1 (positive effect) or with shorter contracts when the odds ratio is below 1 (negative effect).

The three main variables of interest are project field (engineering, chemistry, computing and other fields, this last being the category of reference), the proportion of R&D employees with respect to all the staff of the recipient institution, and the share of the total cost of the contract that is subsidized by the programme. The type of beneficiary of the subsidy (technology centre, large firm or SME, this last being the category of reference) and type of employee (PhD or technician) are also considered for the relevant samples, and, in order to control for unobserved regional heterogeneity, seventeen regional dummies are included as well, i.e. one for each of the Spanish regional autonomous communities.[16]

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[15] We obtain similar results from applying generalized ordered logit models to test the robustness of our findings. Brant tests indicate that the parallel regression assumption is violated for some of the variables considered. The generalised ordered logit model relaxes that assumption and allows the coefficients of the explanatory variables to change from one value of the dependent variable to another. We present the results of the Brant tests and of the generalized ordered logit models in supplementary tables provided at the end of the document. The latter also include the results of likelihood ratio tests which prove to be significant for the assumption that the ordered logit model is nested in the generalized ordered logit, i.e. the former is accurate.

[16] We provide as supplementary material at the end of the document the results of considering a number of specifications that exclude some of the variables appearing in the final regressions set out in Table 5. More precisely, with these alternative specifications we explored the effect of different combinations of explanatory variables in a sequential manner to try to uncover their individual effects, to the extent possible, especially when the variables show some correlation. For instance, for the sample of contracts for technicians, the significance of the positive effect of the share of R&D staff on the duration of the subsidized contract disappears when the type of institution is added, as technology centres tend to have greater shares of R&D staff than firms.

Table 5. Ordered logit: One-, two- or three-yearly instalments awarded for PTQ contracts

PTQ 2002-2004 calls, odds ratios

		Type of contract		Type of host entity	
	All	Technicia	PhDs	SMEs	Technology
S&T worker					
PhD	1.116			1.413**	0.615*
	(0.151)			(0.236)	(0.163)
Project (ref: Other					
Engineering	1.033	1.013	0.964	1.611**	0.480**
	(0.176)	(0.215)	(0.331)	(0.365)	(0.155)
Chemistry	0.967	0.850	0.998	0.999	0.882
	(0.145)	(0.172)	(0.243)	(0.187)	(0.316)
Computing	0.627**	0.579**	0.895	0.661*	0.771
	(0.122)	(0.128)	(0.435)	(0.154)	(0.380)
Type of entity (ref:					
Technology centre	1.944***	3.020***	1.005		
	(0.311)	(0.658)	(0.259)		
Large firm	1.087		1.017		
	(0.312)		(0.311)		
Characteristics of					
Share of R&D in	1.473**	1.202	1.801*	1.418	0.460
	(0.288)	(0.299)	(0.613)	(0.311)	(0.348)
PTQ support					
Share of costs	3.688***	1.818	7.537**	2.965**	5.553
	(1.688)	(1.026)	(6.567)	(1.607)	(6.523)
Regions	Yes	Yes	Yes	Yes	Yes
Constant Cut 1	0.730	0.765	2.592	2.011	0.121*
	(0.295)	(0.404)	(1.932)	(1.007)	(0.137)
Constant Cut 2	2.065*	2.325	7.106**	5.633**	0.437
	(0.835)	(1.235)	(5.294)	(2.829)	(0.490)
Pseudo R-sq	0.0438	0.0628	0.0463	0.0433	0.0743
Log Likelihood	-1130.93	-712.54	-401.47	-773.14	-272.35
Prob > Chi2	0.0000	0.0000	0.0346	0.0000	0.0007
N	1,158	734	424	768	331

Notes: * 0.10, ** 0.05, *** 0.01 significance levels. Robust standard errors in parentheses.Regions are included with 17 regional dummies (one for each Spanish autonomous community)

Several findings are worth noting from the first regression, including all contracts. Firstly, the type of employee, PhD or technician, does not appear to have a significant effect on the duration of the contract. Secondly, contracts to carry out computing projects tend to be terminated earlier than similar contracts in other fields. This may be related to the fact that business cycles are shorter in the computing sector than in other fields, and the projects calling for PTQ employees tend to be shorter as well; opportunities for mobility among research and technicians in this area could be significantly higher. Thirdly, PTQ contracts at technology centres tend to last longer than at firms. Fourthly, the higher the share of R&D staff in the host institution, the longer the contract is likely to last. And, finally, the higher the share of total costs subsidized by the programme, the longer the subsidized contract. This is the effect having the greatest magnitude, which is not surprising. A cheaper contract for an S&T worker is more likely to be renewed. In some cases, depending on the region and the type of institution, the programme may cover nearly 100% of the cost.[17]

It is worth noting, however, that given the high correlation between the type of region (i.e. less favoured) and the maximum amount of subsidy allowed, regional dummies are likely to capture part of the positive effect of the share of contract costs subsidized, especially for the regressions on the subsamples of contracts characterized by more skewed regional distributions, such as those for technology centres. Indeed, five out of Spanish seventeen autonomous communities account for over 70% of all contracts in all categories (Andalusia, the Basque Country, Castile and León, Catalonia and Valencia), and when focusing on subsamples, more than 40% of the contracts for technology centres go to the Basque Country, a region with a long tradition of technology centres, and the Basque Country and Catalonia each receive around 20% of the contracts for technicians.[18]

Regressions for contract subsamples offer some new insights.[19] The regressions by type of contract (PhD and technician) show that the negative association of contract duration with computing projects (relative to other fields) and the positive relationship with technology centres (relative to SMEs) are only significant for technicians. In fact, our results indicate that contracts for technicians tend to be longer at technology centres than at SMEs, regardless of

[17] The magnitude and significance of all these effects in the regression considering all contracts is the same whether we control or not for regional differences (see supplementary tables at the end of the document).
[18] Regressions with and without regional dummies are available as supplementary tables.
[19] Due to the smaller sample size, the models of the subsamples for PhDs and technology centres have lower degrees of significance than those of the subsamples for technicians and SMEs, but we also present them for completeness.

the share of R&D staff at the SME. Moreover, the positive association between contract duration and share of R&D staff is only significant in the contracts for PhDs.

The regressions by type of host entity also present some interesting results. Firstly, contracts for PhDs tend to last significantly longer than contracts for technicians in SMEs, and the opposite holds true in technology centres: under the programme, technicians stay longer than PhDs in technology centres. Secondly, contracts to perform engineering projects tend to last longer than projects in other fields in SMEs, but in technology centres they tend to be significantly shorter. By contrast, contracts for computing projects are likely to be significantly shorter than contracts in other fields in SMEs, which is consistent with results from previous regressions on the full sample and on contracts for technicians, but they are not significantly associated with contract duration in technology centres. Thirdly, the share of costs subsidised is positively associated with contract duration in SMEs, and this holds true regardless of whether regional controls are excluded or included, which is important as contracts for SMEs are more widely spread across the country than contracts for technology centres, for instance.[20] Finally, the share of R&D staff appears to be positively associated with the duration of the subsidised contract at SMEs, but the relationship is weak and appears to depend on the regional economic conditions, as indicated by the fact that it is only significant when the regional controls are excluded.

6. Discussion and policy considerations

This paper presents an analysis of the results of the first calls of Spain's Torres Quevedo Programme, which allocated public funds between 2002 and 2008 to improve the innovative edge of the business sector through employment of highly qualified workers (PhDs and technicians) in firms and technology centres, as S&T personnel.

Acknowledging the limitations of the data available, we believe our findings provide a useful preliminary assessment, in terms of effectiveness, of the extent to which the main objectives of the programme were fulfilled. Determining the factors related to the consolidation of R&D personnel in the organizations subsidised enhances the possibilities of improving such programmes.

[20] See the supplementary tables for the results of the regression on the sample of contracts for SMEs, with and without the inclusion of regional dummies.

In the light of the results, the Torres Quevedo Programme appears to have heightened the absorptive capabilities involving highly qualified workers in the recipient entities, but mostly in the short term. It is indeed puzzling that almost half of the beneficiaries employed the subsidized R&D personnel only as long as an open-ended contract was not required. Just over half (52%) of the contracts subsidised reached the optimal situation foreseen by the programme: the stabilisation of S&T workers as permanent. Is this an indication of the success or failure of the programme? The answer is not clear-cut, especially if the R&D projects undertaken with the aid of subsidised contracts are short-term, or if the person and the firm ended up not being "a good match".

We observed marked differences in persistence between contracts for PhDs and technicians, as well as interesting variations according to organisational type, sector and R&D intensity. With the existing features of the PTQ programme, the type of organisations most likely to retain S&T workers, especially technicians, as permanent employees at the end of the subsidies were technology centres; this was also the case for SMEs with higher shares of R&D personnel. In the SMEs, PhDs tended to have longer contracts as compared to technicians, while S&T workers in general (PhDs or technicians) stayed longer in SMEs having higher shares of R&D staff. This result suggests that new high-tech companies (including spin-offs) were also recipients of subsidies under the group of SMEs.

In view of our findings, the effectiveness of this programme might be hampered by the existence of additional unobservable environmental and business-related factors influencing the duration of contracts. In fact, the programme objective of converting temporary S&T workers into permanent employees was undermined by general regulations in the Spanish labour market at the time, intended to protect permanent workers (as opposed to temporary ones) by radically increasing the cost of layoffs; in this sense, the labour market was rather rigid. Moreover, the objective of transforming subsidised contracts into permanent contracts clashed with certain R&D management practices, especially in SMEs, traditionally reliant on short term project-based management, by definition of limited duration. This trend was coherent with the standard implementation mode of government subsidies, that is to say yearly based. Accordingly, companies needed more time to develop the organisational learning processes that would incorporate R&D as a permanent activity into the strategic management of the organisation.

These interpretations are consistent with the fact that a significant amount of SMEs carry out R&D or innovation activities only occasionally, or tend to use only external R&D resources. Technology centres would thus be key providers of R&D and innovation services for these SMEs. Accordingly, PTQ might have also contributed to the improvement of business competitiveness indirectly, by improving the supply of R&D capabilities from technology centres.

The PTQ objectives were implemented by providing subsidies for firms directly and indirectly, through the improvement of R&D capabilities in technology centres. The programme had the double-edged objective of strengthening R&D capabilities by increasing S&T staff in innovative organizations and of enlarging the number of such organizations. Subsidy policies aimed at enhancing the overall private R&D investment of a given country may follow two different courses of action (Arqué-Castells 2013). On the one hand, they can act on the intensive margin, seeking to promote greater R&D effort by regular/current R&D performers; on the other hand, they can act on the extensive margin, seeking to expand the base of R&D performers. Thus, if the underlying PTQ strategy in the mid- to long term was to consolidate jobs for S&T workers in the beneficiary firms, reinforcing their R&D and innovation capacity, it would make sense to clearly differentiate between aid for technology centres and aid for different types of firms with different programmes. By adjusting the focus of the different subsidies (temporary by definition) to each kind of recipient, thereby increasing the selectivity and focus regarding capabilities in technological centres, cooperation and collaboration with firms is enhanced. Nevertheless, connecting the design of the programme with the conditions of implementation, the fact that a single programme can cater to different types of beneficiaries (firms and centres) lends considerable flexibility to its management. This is especially true in Spain, where programmes are typically not defined *ex ante* in their optimal dimensions; instead, the scale is defined annually, in the light of budgetary availability. PTQ objectives and beneficiaries could therefore be refined to favour selectivity in specific areas or sectors. Furthermore, competing models of R&D subsidies could foster the employability of S&T workers. For instance, tax exemptions would afford more flexibility for recipients, albeit at the expense of policy selectivity and additional impact of the public programme.

If the main objective of the programme in the period considered was to increase the innovative capacity or intensity of businesses, the programme design was probably not ideal for firms starting from scratch in R&D. In such cases, supporting collaboration with private technology centres, or even public R&D centres, may prove more efficient, hiring S&T workers directly (even temporarily) to reach innovative capacity objectives. SMEs that were reluctant to apply to the programme for funding because of its heavy administrative burden (as reflected by the low uptake of the programme among the whole population of SMEs in Spain) might have benefited indirectly through the increased capacities of technology centres.

The fact that fewer than 1,800 contracts were subsidized in the period of study, in around 900 private entities, is a noteworthy finding. Given the vast body of potential recipients, these figures strike us as small. From 2002 to 2008, the number of firms undertaking internal R&D grew very substantially, from 5,500 to 13,000. Still, the most adequate dimensions of the programme remains an open issue, necessarily linked to budgetary restrictions.

Since there were no quantitative objectives defined *ex ante* by the programme (e.g. the number of contracts allocated every year, or the rate of permanence after two years of a contract), it is difficult to assess the finding that half the R&D personnel hired stayed until the third year. A comparison with other systems of incentives shows intriguing results. For example, survival in the other type of public programmes supporting self-employment is reportedly much greater, around 90% (Mato Diaz *et al*. 2004), while the proportion of temporary contracts incentivized to become permanent is similar to the proportion we found in our sample. In terms of the increase of permanent R&D personnel in the private sector with PTQ support, in the light of the aggregate evolution of R&D personnel in those same years, the effect appears minor.

It is also interesting to reflect on the reasons why the contracts approved were later not renewed for a second or third year. In the area of computing, subsidized contracts were shorter than in other areas. Either R&D projects of this type are generally of a shorter duration, or there may simply be a greater turnover among professionals in this sector. Higher turnover and more job-to-job mobility in high-tech sectors, in comparison with the overall economy, are also factors to be considered.

The methodology and the data sources used in this paper do not allow us to follow the path of these contracts after the third year. It would be of great interest for future analysis to study this aspect, completing the existing administrative databases with information retrieval techniques based on surveys, to monitor persistence and job mobility.

Finally, we should acknowledge that the design of the Torres Quevedo Programme has evolved since the period considered in this paper. It would be interesting to update the analysis to include subsidies allocated in the most recent calls. The terms of eligibility have been widened, certain prerequisites for establishing guarantees have been eliminated, and other characteristics of the programme have been modified in the calls published since 2005. Finally, collecting and constructing data in a way that would allow for a quasi-experimental design could broaden the scope of a future evaluation. We leave this for further research.

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Annex

Table A1. Number of yearly instalments awarded to the contracts approved in the 2002-2004 calls

Instalments awarded	All	PhDs	Technicians	SMEs	Technology centres
One	382	143	239	297	64
Two	347	139	208	236	86
Three	778	317	461	494	242
	1507	**599**	**908**	**1027**	**392**
Instalments awarded	**All**	**PhDs**	**Technicians**	**SMEs**	**Technology centres**
One	25%	24%	26%	29%	16%
Two	23%	23%	23%	23%	22%
Three	52%	53%	51%	48%	62%
	100%	**100%**	**100%**	**100%**	**100%**

Table A2. Definitions of variables

Variable		Definition
Characteristics of the S&T worker:		
	PhD	Equal to 1 if the contract is for a PhD, 0 if it is for a technician.
	Woman	Equal to 1 if the contract is for a woman, 0 if it is for a man.
	Years since first degree	Number of years since the beneficiary of the contract obtained first degree.
Scientific areas of the project:		
	Engineering	Mechanical engineering or electrical engineering
	Chemistry	Molecular biology, plant biology, medicine or chemistry
	Computing	Computing
	Other	Physics and mathematics, social sciences, food, agriculture and livestock, materials
Type of entity:		
	Technology centre	Not-for- profit independent legal entity created with the aim of contributing, via technological improvement and management, to better company performance.
	Large firm	Independent legal entity whose main activity is the production of goods and services for the market, including publicly owned firms. As regards size, a large firm is defined by the European Commission as having over 250 employees.
	SME	Independent legal entity whose main activity is the production of goods and services for the market, including publicly owned firms. As regards size, a small and medium enterprise (SME) is defined by the European Commission as having under 250 employees.
Characteristics of entity:		
	Years since creation	Number of years since the creation of the beneficiary entity
	% R&D in total staff	Share of R&D personnel in all staff at the time of the application for funding
	Less favoured region	The location of the entities receiving the funding is classified as Objective 1, Objective 2 or Objective 0, according to the EC criteria. The maximum amount of aid (share of the total cost of the contract that is subsidized) is the highest for Objective 1 regions, corresponding to the less favoured regions. Entities appearing in the PTQ database as located in Objective 1 regions in the period considered are in the following Spanish regional autonomous communities (in alphabetical order): Andalusia, Asturias, Canary Islands, Cantabria, Castile and León, Castile-La Mancha, Extremadura, Galicia, Murcia, Valencia.
Financial features of the contract:		
	Advanced payment of subsidy	Equal to 1 if the beneficiary had asked for advanced payment of the subsidy covering part of the costs related to hiring the S&T worker.
	Salary	First year annual salary (in euros) received by the S&T worker hired through the PTQ programme.
	Share of cost subsidized	Percentage of the first year total cost derived from the contract (annual salary plus charges) for the beneficiary entity
Regions		
	Regional dummies	Seventeen dummies corresponding to each one of the Spanish regional autonomous communities. In alphabetical order: Andalusia, Aragon, Asturias, Balearic Islands, Basque Country, Canary Islands, Cantabria, Castile and León, Castile-La Mancha, Catalonia, Extremadura, Galicia, Madrid, Murcia, Navarra, Rioja, Valencia.

Source: Authors' elaboration based on information from the administrative database of the PTQ programme.

Table A3. Descriptive statistics

Duration of PTQ contracts approved in the 2002-2004 calls, yearly instalments awarded

	All contracts (N=1,507)			PhDs (N=599)			Technicians (N=908)			SMEs (N=1,027)			Technology centres (N=392)		
Number of annuities	One	Two	Three	One	Two	Three	One	Two	Three	One	Two	Three	One	Two	Three
Number of contracts	382	347	778	143	139	317	239	208	461	297	236	494	64	86	242
S&T worker:															
PhD	0.37	0.40	0.41	1.00	1.00	1.00	0.00	0.00	0.00	0.31	0.31	0.37	0.47	0.48	0.38
Woman	0.34	0.41	0.39	0.39	0.48	0.42	0.31	0.37	0.36	0.33	0.40	0.36	0.41	0.45	0.44
Years since first degree	6.91	6.78	7.10	9.18	9.40	9.36	5.57	5.10	5.53	7.00	6.72	7.40	6.11	6.13	6.12
Project:															
Engineering	0.26	0.18	0.26	0.14	0.12	0.14	0.33	0.22	0.33	**0.22**	**0.14**	**0.24**	0.42	0.33	0.31
Chemistry	0.31	0.41	0.35	0.47	0.56	0.51	0.22	0.31	0.25	0.31	0.43	0.37	0.25	0.29	0.26
Computing	**0.14**	**0.13**	**0.08**	0.06	0.05	0.05	**0.18**	**0.18**	**0.10**	**0.17**	**0.16**	**0.09**	0.03	0.08	0.07
Other	0.28	0.26	0.31	0.32	0.25	0.30	0.26	0.27	0.32	0.29	0.26	0.29	0.28	0.27	0.36
Entity:															
Technology centre	**0.17**	**0.25**	**0.31**	0.21	0.29	0.29	**0.14**	**0.22**	**0.32**	0.00	0.00	0.00	1.00	1.00	1.00
Large firm	0.05	0.07	0.05	0.15	0.18	0.13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SME	**0.78**	**0.68**	**0.63**	0.64	0.53	0.57	**0.86**	**0.78**	**0.68**	1.00	1.00	1.00	0.00	0.00	0.00
Years since creation	11.98	12.11	13.06	12.25	13.71	14.53	11.82	11.03	12.05	9.77	9.01	10.03	16.25	16.02	16.33
% R&D in total staff	**0.50**	**0.54**	**0.58**	0.50	0.52	0.58	**0.50**	**0.54**	**0.59**	0.47	0.49	0.52	0.78	0.75	0.76
Less favoured region	0.41	0.44	0.43	0.44	0.38	0.32	0.40	0.47	0.50	0.46	0.48	0.50	0.27	0.29	0.31
Financial features:															
Advanced payment of	0.53	0.58	0.56	0.45	0.48	0.51	0.57	0.64	0.60	0.47	0.50	0.42	0.81	0.87	0.90
Salary (in euros)	27,630	26,217	27,205	30,439	29,862	30,138	26,232	24,273	25,365	27,756	26,283	27,868	25,324	24,406	25,273
Share of cost subsidized	**0.50**	**0.53**	**0.54**	0.51	0.54	0.54	**0.50**	**0.53**	**0.54**	**0.51**	**0.55**	**0.56**	0.47	0.48	0.51

Note: In bold, different distributions (Chi2 test, for dummies) or means (T student test, for continuous variables) at 1% level of significance.

Supplementary tables

Table O1. Correlations, all contracts

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	Instalments awarded	1.0000															
2	PhD	0.0269	1.0000														
3	Woman	0.0313	0.0806	1.0000													
4	Years since undergrad	0.0196	0.3799*	-0.0326	1.0000												
5	Engineering	0.0124	-0.1964*	-0.2173*	-0.1413*	1.0000											
6	Chemistry	0.0213	0.2620*	0.2296*	0.1835*	-0.4161*	1.0000										
7	Computing	-0.0837	-0.1349*	-0.1467*	-0.0687	-0.1907*	-0.2537*	1.0000									
8	Other fields	0.0290	0.0015	0.0535	-0.0084	-0.3585*	-0.4770*	-0.2186*	1.0000								
9	Tech center	0.1355*	0.0253	0.0676	-0.1022*	0.1265*	-0.1095*	-0.0784	0.0426	1.0000							
10	Large firm	-0.0072	0.3066*	-0.0088	0.1066*	-0.0662	0.1338*	-0.0849*	-0.0164	-0.1477*	1.0000						
11	SME	-0.1240*	-0.1781*	-0.0592	0.0434	-0.0858*	0.0358	0.1166*	-0.0319	-0.8673*	-0.3643*	1.0000					
12	Years since creation	0.0351	0.0731	-0.0005	0.0038	0.0777	-0.0282	-0.1626*	0.0637	0.1599*	0.3055*	-0.3043*	1.0000				
13	% R&D in total staff	0.1015*	-0.0119	0.0748	-0.0293	0.0460	0.0053	-0.0031	-0.0392	0.3645*	-0.2064*	-0.2393*	-0.2234*	1.0000			
14	Less favored region	0.0113	-0.1049*	-0.0120	-0.0240	-0.1093*	-0.0417	-0.0220	0.1556*	-0.1591*	-0.0328	0.1665*	-0.1596*	-0.0336	1.0000		
15	Advanced pay of subsidy	0.0244	-0.1061*	0.0552	-0.1124*	0.0530	-0.0790	0.0415	-0.0021	0.3822*	-0.1028*	-0.3081*	0.0236	0.1121*	-0.0443	1.0000	
16	Salary	-0.0097	0.2656*	-0.2095*	0.4440*	0.0633	-0.0175	0.0531	-0.0794	-0.1413*	0.1542*	0.0625	0.0775	-0.0763	-0.1621*	-0.0609	1.0000
17	Share of cost subsidized	0.0958	0.0085	0.0845	-0.1300*	-0.1656*	0.0867	-0.1015*	0.1445*	-0.1208*	-0.0466	0.1371*	-0.1711*	-0.0472	0.6305*	0.0279	-0.3822*

Table O2. Ordered logit: One, two or three yearly instalments awarded for PTQ contracts (All contracts)
PTQ 2002-2004 calls, odds ratios

	All contracts					
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
S&T worker						
PhD	1.053	1.088	1.045	1.162	1.116	1.138
	(0.120)	(0.118)	(0.120)	(0.149)	(0.151)	(0.150)
Project (ref: Other fields)						
Engineering	1.021	1.006	1.003	1.069	1.033	0.980
	(0.153)	(0.151)	(0.151)	(0.180)	(0.176)	(0.163)
Chemistry	1.052	0.976	1.027	0.935	0.967	0.950
	(0.134)	(0.123)	(0.131)	(0.139)	(0.145)	(0.136)
Computing	0.668**	0.629***	0.656**	0.619**	0.627**	0.616**
	(0.116)	(0.109)	(0.113)	(0.122)	(0.122)	(0.116)
Type of entity (ref: SMEs)						
Technology center	1.794***		1.633***		1.944***	1.971***
	(0.237)		(0.226)		(0.311)	(0.281)
Large firm	0.990		1.078		1.087	1.081
	(0.212)		(0.231)		(0.312)	(0.306)
Characteristics of entity						
Share of R&D in total staff		1.692***	1.423**		1.473**	1.492**
		(0.258)	(0.231)		(0.288)	(0.280)
PTQ support				3.863***	3.688***	3.784***
Share of costs subsidized				(1.749)	(1.688)	(1.434)
Regions	Yes	Yes	Yes	Yes	Yes	No
Constant Cut 1	0.325***	0.370***	0.362***	0.653	0.730	0.975
	(0.0791)	(0.0913)	(0.0895)	(0.258)	(0.295)	(0.259)
Constant Cut 2	0.927	1.052	1.034	1.805	2.065*	2.723***
	(0.224)	(0.258)	(0.255)	(0.714)	(0.835)	(0.727)
Pseudo R-sq	0.0260	0.0238	0.0277	0.0302	0.0438	0.0274
Log Likelihood	-1507.94	-1511.46	-1505.29	-1146.93	-1130.93	-1150.28
Prob > Chi2	0.0000	0.0000	0.0000	0.0003	0.0000	0.0000
N	1,507	1,507	1,507	1,158	1,158	1,158

Notes: * 0.10, ** 0.05, *** 0.01 significance levels. Robust standard errors in parentheses.
Regions are included in the analysis with 17 regional dummies (one for each Spanish autonomous community)

Table O3. Ordered logit: One, two or three yearly instalments PTQ contracts 2002-2004 calls (Technicians and PhDs), odds ratios

	Technicians only						PhDs only					
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Project (ref: Other fields)												
Engineering	1.052	1.036	1.032	1.081	1.013	0.895	0.953	0.954	0.953	0.954	0.964	1.082
	(0.196)	(0.191)	(0.193)	(0.222)	(0.215)	(0.180)	(0.279)	(0.280)	(0.280)	(0.325)	(0.331)	(0.335)
Chemistry	1.064	0.952	1.042	0.801	0.850	0.825	0.984	0.976	0.968	1.004	0.998	1.135
	(0.188)	(0.167)	(0.184)	(0.162)	(0.172)	(0.155)	(0.196)	(0.192)	(0.193)	(0.244)	(0.243)	(0.250)
Computing	0.668**	0.629**	0.657**	0.575**	0.579**	0.547***	0.991	0.986	0.976	0.944	0.895	0.871
	(0.133)	(0.127)	(0.131)	(0.127)	(0.128)	(0.117)	(0.391)	(0.373)	(0.374)	(0.480)	(0.435)	(0.389)
Type of entity (ref: SMEs)												
Technology center	2.538***		2.329***		3.020***	2.557***	1.020		0.927	1.137	1.005	1.272
	(0.448)		(0.438)		(0.658)	(0.463)	(0.213)		(0.199)	(0.279)	(0.259)	(0.298)
Large firm							0.879		0.990	0.859	1.017	1.053
							(0.201)		(0.235)	(0.253)	(0.311)	(0.308)
Characteristics of entity												
Share of R&D in total staff		1.850***	1.318		1.202	1.237		1.538*	1.574*		1.801*	2.030**
		(0.377)	(0.284)		(0.299)	(0.292)		(0.373)	(0.417)		(0.613)	(0.638)
PTQ support												
Share of costs subsidized				2.167	1.818	4.032***				8.216**	7.537**	2.893
				(1.169)	(1.026)	(1.837)				(7.138)	(6.567)	(2.028)
Regions	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	No
Constant Cut 1	0.510**	0.550*	0.557*	0.646	0.765	0.865	0.608	0.822	0.818	1.968	2.592	0.910
	(0.168)	(0.192)	(0.189)	(0.341)	(0.404)	(0.275)	(0.227)	(0.342)	(0.354)	(1.399)	(1.932)	(0.442)
Constant Cut 2	1.486	1.576	1.626	1.884	2.325	2.532***	1.805	2.450**	2.438**	5.361**	7.106***	2.373*
	(0.487)	(0.550)	(0.550)	(0.994)	(1.235)	(0.812)	(0.670)	(1.022)	(1.058)	(3.811)	(5.294)	(1.148)
Pseudo R-sq	0.0431	0.0333	0.0440	0.0387	0.0628	0.0383	0.0262	0.0287	0.0288	0.0425	0.0463	0.0147
Log Likelihood	-897.56	-906.77	-896.71	-730.80	-712.54	-731.17	-593.61	-592.11	-592.05	-403.07	-401.47	-414.78
Prob > Chi2	0.0000	0.0002	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0694	0.0346	0.1105
N	908	908	908	734	734	734	599	599	599	424	424	424

Notes: * 0.10, ** 0.05, *** 0.01 significance levels. Robust standard errors in parentheses. Regions are included in the analysis with 17 regional dummies (one for each Spanish autonomous community)

Table O4. Ordered logit: One, two or three yearly instalments awarded for PTQ contracts (SMEs and Technology centers)

PTQ 2002-2004 calls, odds ratios

	SMEs only					Technology centers only				
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 1	Model 2	Model 3	Model 4	Model 5
S&T worker										
PhD	1.228	1.239	1.424**	1.413**	1.389**	0.596**	0.595**	0.618*	0.615*	0.657*
	(0.163)	(0.169)	(0.238)	(0.236)	(0.219)	(0.139)	(0.139)	(0.163)	(0.163)	(0.160)
Project (ref: Other fields)										
Engineering	1.294	1.340	1.632**	1.611**	1.430*	0.526**	0.527**	0.481**	0.480**	0.526**
	(0.244)	(0.260)	(0.369)	(0.365)	(0.299)	(0.149)	(0.150)	(0.155)	(0.155)	(0.154)
Chemistry	1.107	1.103	1.021	0.999	0.989	0.805	0.789	0.912	0.882	0.934
	(0.169)	(0.172)	(0.191)	(0.187)	(0.170)	(0.242)	(0.239)	(0.321)	(0.316)	(0.294)
Computing	0.662**	0.679*	0.672*	0.661*	0.649**	1.026	1.032	0.776	0.771	0.729
	(0.129)	(0.134)	(0.157)	(0.154)	(0.142)	(0.481)	(0.484)	(0.380)	(0.380)	(0.315)
Characteristics of entity										
Share of R&D in total staff		1.355*		1.418	1.425*		0.656		0.460	1.285
		(0.248)		(0.311)	(0.292)		(0.424)		(0.348)	(0.738)
PTQ support										
Share of costs subsidized			3.092**	2.965**	4.072***			6.752*	5.553	5.619*
			(1.670)	(1.607)	(1.790)			(7.806)	(6.523)	(5.234)
Regions	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	No
Constant Cut 1	0.433***	0.971	1.819	2.011	1.189	0.0917***	0.0732***	0.210	0.121*	0.302
	(0.0630)	(0.295)	(0.899)	(1.007)	(0.357)	(0.0613)	(0.0520)	(0.209)	(0.137)	(0.236)
Constant Cut 2	1.194	2.691***	5.079***	5.633***	3.211***	0.317*	0.253**	0.754	0.437	1.006
	(0.171)	(0.823)	(2.519)	(2.829)	(0.969)	(0.206)	(0.175)	(0.740)	(0.490)	(0.783)
Pseudo R-sq	0.0239	0.0264	0.0417	0.0433	0.0198	0.0560	0.0567	0.0723	0.0743	0.0211
Log Likelihood	-1051.35	-1048.63	-774.49	-773.14	-792.17	-342.84	-342.57	-272.95	-272.35	-288.008
Prob > Chi2	0.0000	0.0025	0.0000	0.0000	0.0000	0.0000	0.0000	0.0006	0.0007	0.0277
N	1,027	1,027	768	768	768	392	392	331	331	331

Notes: * 0.10, ** 0.05, *** 0.01 significance levels. Robust standard errors in parentheses. Regions are included in the analysis with 17 regional dummies (one for each Spanish autonomous community).

Table O5. Brant tests for the parallel lines

	All contracts	Technicians	PhDs	SMEs	Technology centers
	p>Chi2	p>Chi2	p>Chi2	p>Chi2	p>Chi2
All variables	0.086	0.097	0.189	0.007	0.813
PhD	0.161			0.009	0.574
Engineering	0.218	0.126	0.557	0.219	0.571
Chemistry	0.090	0.246	0.180	0.029	0.835
Computing	0.458	0.407	0.583	0.494	0.370
Technology center	0.077	0.611	0.017		
Large firm	0.790		0.659		
Share of R&D in total staff	0.961	0.682	0.642	0.855	0.454
Share of costs subsidized	0.208	0.445	0.202	0.257	0.961

Table O6. Generalised ordered logit: duration of PTQ contracts

PTQ 2002-2004 calls, odds ratios

	All contracts		Technicians		PhDs		SMEs		Technology centers	
	One year	**Two years**	**One year**	**Two years**	**One year**	**Two years**	**One year**	**Two years**	**One year**	**Two years**
S&T worker										
PhD	0.985	1.211					1.123	1.581***	0.740	0.632*
	(0.156)	(0.165)					(0.200)	(0.258)	(0.258)	(0.161)
Project (ref: Other fields)										
Engineering	0.828	1.045	0.704	1.002	1.112	1.029	1.217	1.517**	0.430**	0.554**
	(0.158)	(0.174)	(0.164)	(0.203)	(0.399)	(0.327)	(0.276)	(0.318)	(0.176)	(0.166)
Chemistry	1.125	0.868	0.967	0.751	1.383	1.024	1.242	0.850	0.802	0.952
	(0.203)	(0.133)	(0.240)	(0.155)	(0.366)	(0.232)	(0.259)	(0.158)	(0.419)	(0.306)
Computing	0.675*	0.577**	0.609*	0.496***	0.798	0.924	0.697	0.604**	1.334	0.652
	(0.155)	(0.125)	(0.160)	(0.124)	(0.379)	(0.397)	(0.172)	(0.149)	(1.078)	(0.317)
Type of entity (ref: SMEs)										
Technology center	2.591***	1.826***	2.945***	2.489***	1.964**	1.077				
	(0.497)	(0.273)	(0.717)	(0.466)	(0.607)	(0.269)				
Large firm	1.168	1.060			1.088	0.999				
	(0.381)	(0.310)			(0.379)	(0.307)				
Characteristics of entity										
Share of R&D in total staff	1.475*	1.467**	1.318	1.164	1.755	2.067**	1.488*	1.369	0.620	1.493
	(0.326)	(0.285)	(0.375)	(0.290)	(0.680)	(0.662)	(0.359)	(0.297)	(0.728)	(0.889)
PTQ support										
Share of costs subsidized	5.460***	3.080***	5.677***	3.423**	4.034*	2.208	5.435***	3.331**	6.194	5.708*
	(2.466)	(1.218)	(3.180)	(1.651)	(3.339)	(1.606)	(2.796)	(1.587)	(9.636)	(5.237)
Constant	0.832	0.424***	0.933	0.450**	0.823	0.541	0.714	0.356***	5.863	0.880
	(0.252)	(0.117)	(0.345)	(0.152)	(0.437)	(0.266)	(0.237)	(0.115)	(8.255)	(0.694)
Pseudo R-sq	0.0343		0.0467		0.0251		0.0300		0.0281	
Log Likelihood	-1142.0963		-724.73005		-410.3778		-783.94268		-285.93908	
Prob > Chi2	0.0000		0.0000		0.1318		0.0000		0.1098	
N	1,158		734		424		768		331	
Likelihood ratio test, p>chi2 (Assumption ologit nested in gologit)	0.0374		0.0450		--		0.0114		0.6578	

Notes: * 0.10, ** 0.05, *** 0.01 significance levels. Robust standard errors in parentheses.