The relationship between research funding and academic consulting:

An empirical investigation in the Spanish context

Pablo D'Este[a], *Francesco Rentocchini*[ac #], *Rosa Grimaldi*[b], *Liney Manjarrés-Henríquez*[ad]

[a] *INGENIO [CSIC-UPV], Universidad Politécnica de Valencia, Spain*
[b] *Department of Management, University of Bologna, Italy*
[c] *Department of Economics and Management, University of Trento, Italy*
[d] *Departamento de Ingeniería Industrial. Universidad Autónoma del Caribe, Colombia*

Acknowledgements: A preliminary version of this paper was presented to the Conference "The Governance of a Complex World", Nice, 1–3 November 2012. The authors are grateful to the conference participants for their comments and suggestions. We would like to thank two anonymous referees and the editors of the Journal for their very useful and detailed comments. Pablo D'Este acknowledges support from the Spanish Ministry of Economy and Competitiveness (ECO2011-28749). Francesco Rentocchini acknowledges funding from the Autonomous Province of Trento (Grant 2009 Outgoing: OVERNET). The usual caveats apply.

[#] Corresponding author: Department of Economics and Management, Faculty of Economics, via Inama 5, 38122, Trento, Italy, e-mail: francesco.rentocchini@economia.unitn.it, Tel: 0039 0461 882162, Fax: 0039 0461 882222

Abstract

This paper investigates the relationship between sources of funding for research activity and the engagement of scientists in a specific type of knowledge transfer, that is, academic consulting. We rely on a sample of 2,603 individual scientists from five Spanish universities, who have been awarded public funding or have been principal investigators in activities contracted by external agents, over the period 1999-2004. We find that externally contracted research is positively related to the amount of monetary income from consulting contracts, but that international competitive funding has a negative effect. Our results show that this negative effect is positively moderated by the size of contract funding: the effect of international competitive funding becomes positive for moderate and high levels of contract funding. By investigating the relationship between academic consulting and different types of research funding, our paper sheds light on the conditions that favour consulting.

Keywords: academic consulting; technology policy; knowledge and technology transfer

1 Introduction

Academic researchers are increasingly being required to produce excellent research and to demonstrate the economic and social relevance of publicly funded research. This balance between research excellence and utility is not always easy to achieve. Striking a balance between efforts oriented towards knowledge creation and efforts directed to effective transfer of knowledge to potential users can be difficult, and the findings are unclear about whether research activity and knowledge transfer are in conflict or are complementary [13; 16; 22; 23].

In this study we investigate the relationship between extramural sources of funding for research and engagement in a specific type of knowledge transfer - academic consulting. While we acknowledge that knowledge transfer can take other forms, including patenting activity and licensing of intellectual property rights, spin-off creation and joint research collaboration with industry [12; 20], we focus on academic consulting for the following reasons. First, academic consulting implies direct, personal interaction between scientists and users, and a purposeful (often bi-directional) effort to agree on expected goals and to deliver actionable knowledge and expertise. Second, academic consulting is a widespread phenomenon compared to other contractual (i.e. licensing) or relational (joint research) channels of interaction with non-academic organizations [18; 26]. Third, consulting is generally rather overlooked in the literature, partly because the often informal nature of consulting activities makes them difficult to trace systematically [6; 24].

In relation to extramural funding, we look at various sources of research money and distinguish between competitive and contract funding. Competitive research funding refers to regional, national or international grants awarded by public funding agencies based on peer-review of the research proposals from university scientists. Contract research funding refers to funding obtained by university scientists from sponsoring agencies (public or private partners) who often set the targets of the research being contracted.

We test our hypotheses on the relation between faculty access to extramural research funding and their involvement in consulting activities on a sample of 2,603 individual scientists from five Spanish universities, who received research funding in the period 1999-2004. We exploit the longitudinal nature of our data and estimate several linear and non-linear panel data models, which controls for unobserved heterogeneity and censoring in the data. We find that the amount of research financed through R&D contracts increases the amount of monetary income from consulting. In contrast, funding for research from international sources has a negative effect on the amount of consulting activity. However, this negative effect is positively moderated by the amount of contract funding, pointing to a complementary effect of competitive and contract funding on the level of consulting activities.

The paper is structured as follows. Section 2 provides the theoretical background to the paper; Section 3 presents the dataset and describes the sample used for the empirical analysis. Section 4 specifies the econometric models and the variables used. Section 5 summarizes the results of the econometric estimates, and Section 6 synthesizes the main findings, discusses some limitations of this study and proposes some directions for further research.

2 Theoretical background

2.1 Defining academic consulting

Several authors argue that consulting is a strategy for transferring knowledge between academic scientists and decision-makers in companies and government agencies, and it can be particularly effective to enhance interactive and problem-solving knowledge [19; 20; 27]. However, whether consulting distracts academics from *doing research* or whether research and consulting are activities that can be conducted simultaneously without harm to either [26; 28] remains an open question. Before addressing this question we need to agree on a definition of academic consulting.

Following Perkmann and Walsh [26], we define academic consulting as the provision of a service by academics, to external organizations, on commercial terms, which may involve providing advice and solving specific problems. Consulting is not aimed at generating new scientific or technological knowledge; it is instead often meant to promote or facilitate technical and/or organizational innovation.[1] Consulting services can take various forms, such as technical expertise, advice, fact finding or intermediating roles depending on the contracting partner's needs [8].

[1] In adopting this definition, we are in line with the definition of consulting activity of the Technology Transfer Offices in Spain and that of others such as Jacobson et al. [17], who define consulting as: '(…) a process of transferring expertise, knowledge, and/or skills from one party (the consultant) to another (the client) with the aim of providing help or solving problems' (19: 302).

Bozeman and Gaughan [3] point out that income from consulting is not generally considered ‘university funding’ since consulting agreements typically do not provide institutional funds (except in the form of university overheads) and are arranged on a bilateral basis with the individual researchers. Bozeman and Gaughan argue that the university’s input to individual consulting contracts is mainly setting the amount of time that can be devoted to consulting, resolving conflicts of interest and setting the rules on use of university resources and level of personal income that researchers can earn from consulting.

Perkmann and Walsh [26] refer to research-driven consulting or opportunity-driven consulting depending on the researcher’s motivations. Research-driven consulting is expected to be positively related to the academic’s research projects; opportunity driven consulting is expected to be negatively associated with his/her research and aimed at boosting personal income. This characterization underpins our research questions on the complementarity or substitutability of scientists’ efforts in research-driven activities and their involvement in consulting activities.

2.2 Relationship between research funding and involvement in consulting

Research activity requires funding – sometimes large amounts. Goldfarb [13] describes research as ‘a sponsored activity’. However, who sponsors the research and how the research funding is channelled to the academic researcher can have a major influence on the balance between excellence and utility of research activities. There are two main types of funding for research: competitive funding and contract funding [3, 10, 11].

Competitive funding refers to public funding awarded to scientists by national science ministries, research councils or international institutions (e.g. European Commission Framework Programmes). These agencies allocate funds through research grants, awarded on the basis of peer review to determine the scientific merits of proposals and applicants. It is awarded in a competition among several proposals. The most outstanding projects (measured by applicant's scientific profile and research content) are awarded funding. While a variable proportion of competitive funding might depend on government targets, the system is characterized by being mainly a bottom-up process in which applicants (typically, university scientists) propose lines of research they believe will make a relevant scientific contribution, and to which they are attracted based on their personal research background.[2] Competitive funding is generally awarded to support high impact scientific production and allows the successful researchers to follow a curiosity-driven research agenda. In other words, competitive government funding prioritizes claims to and demonstration of scientific excellence over utility.

In the relationship between competitive funding for research and academic consulting, there seem to be two conflicting logics at work. On the one hand, a 'research orientation' effect: if grant holders are oriented predominantly towards curiosity-driven research and conformance with the norms of science such as priority and scientific impact, they are less likely to be concerned about attracting the attention, or identifying potential users, of their research results. Based on this reasoning, we expect grant holders to be concentrated on knowledge advancement and contributing

[2] Funding from foundations to support research projects may fall into this category. However not all research projects financed by foundations come under competitive funding. Foundations can be part of a public or private institution and usually have well-defined missions with the result that they are equally likely to provide funding for targeted contract research.

to the scientific debates in their specific research fields. In this case, they are less likely to search for personal remuneration from consultancy. This supports the hypothesis of a substitution effect, since researchers with large amounts of funding from competitive grants will be less likely to engage in consulting activities.

On the other hand, there may be a ‘signalling’ effect. Academics who excel at raising competitive funding for research are either outstanding scientists with good track records of highly cited work or scientists with promising research agendas that are likely to impress potential users of university research. Medium and large firms in particular, that invest in R&D and innovation, may be attracted to these scientists’ outstanding research profiles and scientific-related expertise [3]. Companies might want these outstanding scientists to lead their consultancy projects on the basis of their reputation, as this will give their consulting agreements greater visibility and scientific legitimacy. This signalling logic supports the argument of a complementary effect, since researchers in receipt of large amounts of funding from competitive grants will be more visible and more in demand for consulting services.

Following this discussion we formulate competing hypotheses:

> *H1a. Academic scientists with large amounts of competitive funding for research will exhibit lower levels of involvement in consulting activities.*

> *H1b. Academic scientists with large amounts of competitive funding for research will exhibit higher levels of involvement in consulting activities.*

Contract funding is characterized by being a more demand-driven process in which the sponsoring agency - whether a public or a private organisation - allocates money for research on the basis of tendering for applications, or direct links to a university research team. Research contracts usually have well-specified goals and are more mission-oriented than projects funded by competitive grants. Contract funding is usually shorter term than grant funding, and generally involves more applied than fundamental or basic research. Geuna [10] and Goldfarb [11] argue that the increased importance of the contract channel for funding research, in part is a response to pressure from policy makers for scientific research to be more relevant and more oriented to socially useful goals. Although contract funded research involves knowledge creation and scientific production, its main objective is satisfy the research sponsor's goals, which may not necessarily require scientific excellence. Thus, research sponsoring agencies providing contract funding prioritize and make mandatory the production of useful results based on agreed goals, over achievement of scientific excellence.[3]

There are two main arguments supporting a positive relationship between contract funding and academic consulting. One is based on the 'embedded' logic: consulting activities can be linked directly to the researcher's sponsored research activity. In this sense, some consulting activity may be integral to the co-production of knowledge by the contracting agent and the academic scientist [26]. However, Goldfarb [11] points

[3] It is important to differentiate between contract research and consulting because their boundaries are often blurred. While the flows of knowledge from scientists to external contractors related to consulting activity and contract research may show strong similarities in that both activities are short term and applied academic research knowledge is transferred to an external client, there are two main differences. First, contract R&D is oriented to providing funding for research and knowledge generating activities, while consulting refers to contracted services based on existing knowledge, which is provided by the university scientist to the contractor partner. Second, contract R&D funding is controlled by the university (the administration authorizes use of this funding by the principal investigator) while consulting agreements result in personal earnings for the individual scientist (with a percentage deducted for university overheads).

to the risk of a path-dependent process where scientists who engage predominantly in sponsored contract research experience a reduced likelihood of producing important insights and discoveries and become trapped within a narrower range of funding opportunities, that is, funding mainly oriented to satisfying the specific needs of sponsors, and consulting activities.

The second argument draws on the ‘network’ logic, which builds on the idea that involvement in research projects sponsored by industry or a government agency improves scientists’ understanding of the context of application of their research and develops their skills. It ensures the achievement of agreed targets and delivery of useful results, and reduces conflicts of interest and the cultural barriers to the exchange of codified and tacit knowledge [4]. In this context, personal relations with industry are important. Longer collaboration experience (which reinforces personal relationships) from engagement in sponsored research projects, creates better trust relationships with non-academic organizations and is the basis for strong and weak ties with external organizations. Further collaboration and exchange between the contracting agent and the researcher are likely, perhaps involving the researcher acting as a consultant for subsequent stages of a specific research project, after the current contract with the researcher/university has ended.

Being considered a trusted academic partner, and having a wide network of potential sponsors, are likely to increase the opportunities for further consulting activities. There is some empirical evidence showing that the involvement of academics in industry-sponsored research increases the probability that scientists engage in consulting activities [6, 20]. Based on this discussion, we propose the following hypothesis:

> *H2. Academic scientists who receive larger amounts of contract funding for research, will exhibit higher levels of involvement in consulting activities.*

Finally, we argue that striking a balance between conducting research and engaging in knowledge transfer activities, such as consulting, depends on the interplay between competitive and contract R&D funding. The network and the embedded logics associated with contract research funding are likely to moderate the impact of competitive funding on consulting activities since, as discussed above, contract research helps to improve scientists' understanding of the context of application of their research and enhances their awareness of the potential uses of their research. In this sense, combining competitive and contract funding should facilitate a balance between the quest for research excellence, usually associated with competitive funding, and the aim of producing useful research, typical of contract funding [23]. For instance, the first of our alternative hypotheses (i.e. H1a) argues that the scientist's research orientation might have a negative effect on consulting activity (the research-orientation effect). However, when scientists are in receipt of both competitive and contract funding, the network effect adds to the 'research orientation' making scientists more aware of and attentive to the potential application of their outstanding research results. Thus, we expect that the propensity for scientists with competitive funding for research to undertake consulting activity will increase with greater exposure to the potential applications of research from contract funded projects. We therefore propose the following hypothesis:

> *H3. The impact of competitive funding on the degree of involvement in consulting activities is positively moderated by the amount of contract funding available for research.*

3 Data sources and descriptive statistics

3.1 Spanish research context

The main features characterizing the organization and structure of the current Spanish research system are largely the result of the Science Law (Ley de la Ciencia) passed in 1986 (Munoz & Sebastian, 2008; Yegros, 2011). This Law made R&D a priority on the political agenda, and established the National Plan as the main mechanism of public funding for university research. The first National Plan covered the period 1988-1991, since when there have been five more research National Plans. The time frame of the present study coincides to a large extent with the 4th National Plan (which covered the period 2000-2004). Figure 1 shows that the total amount of public funding for R&D grew steadily over the period covered by this study.

To understand the context of the present research we highlight two policy initiatives that were implemented during the period analysed. In 1997, the Spanish Conference of University Vice-Chancellors (CRUE) - the main organization intermediating between universities and national government in Spain - strongly endorsed the development of technology transfer structures by contributing to the creation of the

Network of Technology Transfer Offices, RedOtri. The RedOtri network was designed to facilitate and promote a match between the scientific activities being conducted in universities and the needs of the social and economic environment.

In 2001, the University Law (i.e. Ley Orgánica de Universidades, LOU) was revised in order to achieve a better alignment between the Spanish university system and the objectives of the European Research Area. The LOU placed strong emphasis on the linkages between university research and the creation of wealth, stressing the role of new technology based firms spun off from universities as vehicles of technology transfer. There was increased public support for R&D during most of the 1990s and the first decade of 2000 accompanied by increased income from contracts and consulting agreements in the same period (see Figure 1). This steady and continuously increasing trend in available funding for research provides the background to this study. In what follows we describe the main sources of the data used in this study, and present the results of econometric analysis of the relationship between competitive and contract research and consulting.

[Figure 1 in here]

3.2 Data

The main data sources are the administrative records of the technology transfer offices of the five public universities in the Valencian higher education system: University of Alicante (UA), Miguel Hernández University (UMH), Jaume I University (UJI), University of Valencia (UV), and the Polytechnic University of Valencia (UPV). With the exception of the University of Valencia, all these universities were created since 1970. The data are analysed at the individual level. Our sample consists of 2,603 research active scientists, that is, academics who have been awarded public grants or have been principal investigators on R&D contracts, in the period 1999-2004.

Our sample is distributed across the five universities considered in this study as follows: 37% UV; 28% UPV; 12% UA; 13% UJI; 10% UMH (which distribution largely mirrors the populations of faculty in the 5 universities).[4] A value added feature of these data is that they provide detailed, time varying, project level information on the contractual arrangements of academic researchers in the period 1999-2004. Contractual arrangements include competitive funding agreements (funding from public organizations), contract funding agreements (funding from industry or public administrations), and academic consulting agreements. The data provide the number of consulting contracts in which researchers engaged, and the amounts of money derived from this source.

3.3 Academic consulting

To understand the nature of our data on academic consulting, we provide a brief overview of the regulation governing the contractual arrangements that university researchers are allowed to establish with non-academic agents.

[4] The distribution of the population of scientists working in the Valencian higher education system is: 40% UV; 30% UPV; 17% U.A; 8% UJI; 6% UMH. This distribution compared to the distribution of scientists in our sample is particularly similar for the two largest universities (i.e. UV and UPV), which account for almost 70% of the overall population of scientists.

In the Spanish context, university-industry linkages are regulated by the LOU-2001, specifically Article 83. It gives authorization for academic researchers to sign agreements with public or private organizations for the development of work of a scientific, technical or artistic nature, and for the development of specialist courses or specific activities associated with training. Thus, academics have the power to make contractual arrangements with companies (and public administrations), and sign advisory and consulting agreements with them, provided that these contracts are approved by the university and administered by the university structure responsible for channelling knowledge and for technology transfer activities.

Under the University Law, each university has autonomy to establish procedures for authorizing and monitoring consulting agreements, and set the criteria for final ownership of the assets and resources resulting from these agreements. For example, UPV retains 10% of the total funding received from an external agent, as overheads, the remainder being allocated to cover the costs of materials for the development of planned tasks, and remunerate the academic scientist responsible for implementing the activities described in the consulting contract. Faculty remuneration from involvement in consulting activities must not exceed 1.5 times the annual salary of the highest category of academic faculty, that is, full-time professor.[5]

Within this legal framework, consulting activities are identified as well-defined activities developed under contractual agreements. More specifically, the purpose of consulting is to provide activities to solve specific problems and provide qualitative advice, but not to generate new scientific or technological knowledge. Consulting

[5] UPV's Management Regulations for Research, Technology Transfer and Continuing Education, BOUPV 43, http://www.upv.es/entidades/SG/infoweb/sg/info/U0537298.pdf.

may be aimed at promoting or facilitating technical and/or organizational innovation. Such contracts refer to technical and professional work, and design and technology support for industry. Consulting also includes technical services (e.g. data analysis, testing), which normally take the form of specialist equipment and skilled personnel in research centres.

Based on this characterization of academic consulting, such contractual arrangements are frequent among faculty in the universities analysed. Table 1 shows that 46% of our sample of academic researchers were involved in at least one academic consulting arrangement in the period 1999-2004. The proportion of scientists involved in academic consulting is systematically higher than the proportion of scientists involved in research contracts regardless of the scientific field, but there are significant differences by scientific discipline in the *level* of engagement in consulting activities. Scientists in engineering-related fields show a much higher propensity to engage in academic consulting – more than 70% of scientists in Engineering engaged in academic consulting over the five-year period analysed, compared to 46% of Social Sciences and 32% of Mathematics and Physics faculty.

[Tables 1 and 2 in here]

The amount of money involved in different contractual agreements differs substantially according to the type of contract. Table 2 shows that, on average, consulting agreements (column 1) involve smaller sums of money than contract funding (column 2) and competitive funding (columns 3 and 4). The average amount for each of the three types increases as we move from consulting to contract funding, to competitive funding, largely because consulting contracts are usually shorter term, and involve smaller time inputs by the principal investigators, compared to contract funding and competitive funding. Competitive funding includes two types of funding agreements (i.e. national and international); national grants differ substantially from international grants in the resources mobilized and the review processes involved in their assessment and the final award decision.

4 Econometric model

4.1 Dependent variables and methods

As discussed in Section 2.2, we are interested in examining the relationship between research funding and academic consulting at the level of the individual scientist. The model can be written as:

$$VConsulting_{it} = \alpha + x_{i,t-1}^{T}\beta + \delta^{T}Z_i + \mu_i + \varepsilon_{it}$$

where $VConsulting_{it}$ is the dependent variable, measured as the natural logarithm of the total amount (plus 1) of consulting conducted by scientist i in year t; $x_{i,t-1}$ denotes the set of time-varying covariates measured at time $t-1$ to control partially for reverse causality issues (see Section 4.2); Z_i indicates a series of individual-specific control variables (see again Section 4.2), μ_i is the unobserved individual-specific effect, and ε_{it} is the error term. We measure the extent of engagement in consulting using information from our dataset. In particular, we use the total monetary income from consulting contracts obtained by the scientists in the sample. We spread the contract value over the whole award period, that is, for a two-year contract we divide it equally across the two years. This accounts for the on-going benefits and implications of the contract and mitigates against the effect of all the funding being focused on the beginning of the period.

To study the relationship between scientists' sources of funding and the extent of their engagement in consulting activities we investigate which of the multiple sources of funding available to researchers influences the amount of consulting undertaken. We employ different specifications of our panel data model: pooled cross-sectional approach, random effects estimator, censored random effects estimator and a fixed effects estimators.

First, we assume that $\mu_i = 0$, therefore, the model can be estimated as a simple pooled cross-sectional model, adjusting for standard errors for individual clusters to account of the panel structure of the data. Thus, we allow the error terms to be correlated within individual observations. Although useful as starting point, the pooled model has the disadvantage that it does not control for unobserved time-invariant factors, such as scientist's ability, which are relevant for consistent estimation of the coefficients of the regression model. Next, we apply a random-effects panel estimator so that μ_i is different from zero. However, this requires the assumption that the unobserved heterogeneity term distributed with the mean equals the average of the individual effect. In the third version, we apply a random-effects Tobit panel data estimator to deal with censoring of the data (i.e. $VConsulting_{it}$ takes the value 0 in 54% of cases). Finally, we apply alternative fixed-effects panel data estimators, which dispenses with the unobserved heterogeneity term, thus fully controlling for its influence on our estimates. In particular, we apply a within estimator that eliminates all time-invariant regressors and is able to provide consistent estimators for the time-variant regressors. By definition, the time-invariant regressors are not estimated because they are not identified. Therefore, we employ the Hausman-Taylor estimator, which is an instrumental variable estimator that allows estimation of the coefficients of the time-invariant covariates [15].

4.2 Independent and control variables

Our main independent variables (see Section 2.2) refer to the different sources of funding available to the individual scientist, that is, the amounts of competitive and contract funding. These variables are defined as stocks (rather than flows) because we expect a scientist's rate of engagement in consulting to be affected by the cumulated stocks of funding not just by current or lagged flows. Moreover, using stocks variables overcomes a potential endogeneity problem from using flows. In this framework, the stocks variables are computed using the perpetual inventory method based on the following formulas:

$$Stock_{X_t} = Stock_{X_{t-1}}(1-\delta) + Flow_{X_t}$$

$$Stock_{X_{t_0}} = \frac{Flow_{X_{t_0}}}{(g+\delta)}$$

As far as the pre-sample growth rate g for *Xs* is concerned, we assume it to be equal to the average growth rate of *X* in our sample over the period 1999-2004. For the depreciation rate (δ) for *Xs*, we follow the literature and assume a constant value of 0.15 [2; 14].[6]

The stocks variables are $VContract_{i,t-1}$, which is the natural logarithm of the stock of

[6] However, contract funding and competitive funding can refer to other aspects than knowledge accumulation. Thus, we control for the sensitivity of our results to different values of the depreciation rate. We re-ran the estimates for values of the depreciation rate between 0.05 (5%) and 0.45 (45%). Neither the significance nor the sign of our main covariates changed even for widely differing values of the depreciation rate. The results of the sensitivity analysis are available on request from the authors.

funding (plus 1) to support research activity, provided by external agents (firms, public administrations, other individuals, etc.) to scientist *i* in year *t-1*. As already mentioned, for competitive funding, we distinguish between international competitive funding (financed by international public institutions) and national competitive funding (financed by national/regional public institutions). Specifically, $VCompetNat_{i,t-1}$ is the natural logarithm of the stock of funding (plus 1) to support research activity, obtained via competitive funding at the regional and national levels (e.g. National Plan Standard Grants[7]) by scientist *i* in year *t-1*. $VCompetInt_{i,t-1}$ is the natural logarithm of the stock of funding (plus 1) to support research activity, obtained via competitive funding at the international level (e.g. EU funded projects) by scientist *i* in year *t-1*.

The other explanatory variables, which act mainly as controls, are Exp_i which is a proxy for work experience and is measured as the number of quinquenios[8] obtained by the scientist. We also computed the number of sexenios awarded to an individual (relative to the number of years in academia) to measure the 'research ability' of the scientists in our sample.[9] This variable ($ResAb_i$) is a ratio that ranges between 0 (no sexenios) to 1 (maximum number of sexenios an individual can be granted based on his/her experience in academia). The closer to 1, the greater the research ability of the scientist. We control also for status, and the operational environment and field of the scientist. In particular, we control for the effects of the scientist's academic position

[7] The National Plan standard grants are the main national level competitive grants available to Spanish academic researchers (see www.idi.mineco.gob.es for further details).

[8] The *quinquenio* (literally 5-year period) is a form of recognition granted to academic scientists based on their experience, which affects their salaries. *Quinquenios* are awarded every 5 years, following an evaluation process. Thus, a professor with 20 years tenure in a university could have 4 *quinquenios*. We use *Quinquenio* to proxy for academic experience.

[9] Sexenios are awarded for outstanding research performance over a 6 year period, by the National Commission for the Assessment of Research Activities (CNEAI – Comision Nacional Evaluadora de la Actividad Investigadora), based on a peer-review process that assesses the quality of the scientist's 5 main contributions (mainly journal articles) during a 6 year period. A sexenio signals research accomplishment and it has a positive impact on the scientist's salary.

(*DAcademicPosition*$_i$)[10] and university affiliation (*DUniversity*$_i$), and year (*DYear*$_i$) using a series of specific dummies. Finally, we control for the specific effects of the scientific field using a series of field-specific dummies.[11]

Table 3 presents the correlation matrix for the time variant variables included in our analysis (*VConsulting*, *VContract*, *VCompetNat*, *VCompetInt*) and the variables for individual experience (*Exp*) and research ability (*ResAb*). Table 3 shows that the variables are weakly correlated, suggesting that our data are not subject to multicollinearity problems.

[Table 3 in here]

5 Results

The empirical analysis focuses on the relationship between different sources of research funding and the monetary income from consulting contracts of the individual scientist, and is based mainly on panel data model estimations to control for unobserved heterogeneity.

In this section we present only the results for the most reliable models based on fixed effects estimates (within estimator and Hausman-Taylor model) for the overall sample of 2,603 individuals.[12] The regression results are reported in Table 4. The first and second columns present the fixed effects panel data estimators (within estimator and Hausman-Taylor respectively) to test hypotheses 1a/1b and 2. Columns 3 and 4 include the respective interaction terms (*VContractXVCompetNat* and

[10] Academic position refers to the categories of lecturer, profesor and other.

[11] Following the standard classification provided by UNESCO [29], we considered the following scientific fields: (i) Agricultural, Biological and Medical Sciences; (ii) Social Sicences; (iii) Humanities; (iv) Mathematics and Physics; and (v) Engineering and Technology.

[12] The choice of these models is supported by a Hausman test of fixed vs random effects. Results of the other models are available from the authors on request.

VContractXVCompetInt) for the Hausman-Taylor specification in order to assess the validity of hypothesis 3. The results in Table 4 show that the amount of contract funding for research - *VContract* - has a positive impact on the extent of engagement in consulting activities. This result supports hypothesis 2. According to the fixed effects model, doubling the amount of contract funding for research increases the amount of funding from consulting contracts by 3%.

The amount of competitive funding obtained at the national level –*VCompetNat* - has a non-significant effect and the amount of competitive funding obtained at the international level –*VCompetInt* – has a negative and significant effect, according to results in Table 4 Columns 1 and 2. Thus, doubling the amount of international competitive funding for research decreases the amount of funding from consulting activities carried out, by 4%. Overall, the non-significance of competitive research funding at the national level, and the negative and significant effect of competitive funding at the international level, provide support for hypothesis H1a.

Table 4 also presents the results of the Hausman-Taylor specification for the interaction between contract research and competitive international and national funding. While the interaction between *VContract* and *VCompetNat* is not significant, the interaction between contract research and competitive funding at the international level is positive and significant at the 1% level. This means that contract research has a positive moderating effect on the negative relationship between competitive funding at the international level and the amount of funding from consulting activities. It is interesting that the positive moderating role of contract research affects the negative relationship between *VCompetInt* and *VConsulting* which eventually turns positive. Figure 2 plots the linear prediction of our model for *VConsulting* for different levels of *VCompetInt*. Each line in the graph represents a linear prediction for different values of *VContract.* The slope initially is negative, but turns positive for moderate and high levels of contract funding. This result provides support for hypothesis 3.

[Figure 2 in here]

Regarding the control variables, the coefficient of *Exp* is positive and significant at conventional confidence levels in all the specifications. As expected, experience has a positive effect on consulting contracts. The coefficient of *ResAb* is negative and significant across all specifications, meaning that research productive scientists are less likely to engage in consulting contracts. Interestingly, all the other controls are significant at the joint level (dummies for Position, Time, University and Field). **Table 4** also presents the results for the scientific field dummies, which provide information on the effect of different scientific areas on the extent of consulting activity. As reported in Table 4, the coefficients of *Humanities* and *Mathematics & Physics* are significant and negative, meaning that scientists in these fields are expected to engage less in consulting than scientists in *Agricultural, Biological & Medical Sciences* (the reference category), while *Engineering & Technology* has a positive and significant coefficient.

[Table 4 in here]

6 Conclusion

In this paper, we analysed the relationship between sources of funding for research and scientists' engagement in a specific type of knowledge transfer, that is, academic consulting. We used a unique dataset providing project-level information on funding for 2,603 individual faculty from five Spanish universities in the period 1999-2004, and applied a panel data econometric approach.

We found a positive relationship between contract funding and the monetary income from consulting contracts at the individual level, and a negative effect of international competitive funding. In line with the results in Muscio et al. [23] for the department level, we find a positive moderating role of amount of contract funding on the negative relationship between competitive international funding and consulting.

We interpret the relationship between scientists' access to these two types of extramural research funding and their engagement in consulting activities in terms of networking, research orientation and signalling effects. On the one hand, the researchers might gain a reputation of trusted partner among contracting agents (network effect). On the other hand, if grant holders are predominantly oriented towards curiosity-driven research and the norms of priority and scientific impact of science, they are likely to be less focused on attracting or identifying potential users (research orientation effect). This latter effect holds only in relation to international competitive funding, generally related to large budgets, consortia among academic network members, and more basic-oriented research.

However, the effect of international competitive funding on consulting is moderated and eventually becomes positive at fairly low levels of contract funding. This finding supports the argument that combining competitive and contract funding facilitates a balance between the quest for research excellence and the aim of research relevance for its potential users.

This paper, in the spirit of this Special Issue, makes two contributions to the literature. First, it contributes to the extensive academic debate on university-industry interactions by moving beyond technology transfer and studying ‘softer’, less easily traceable channels of interaction [31]. Several authors have highlighted that technology transfer channels (i.e. patents or licensing of intellectual property) are not representative of all the patterns of knowledge generation and transfer from public research organizations [1, 5]. However, the prevalence of these other forms of university-industry collaboration and their internal functioning have been rather unexplored [25].

We contribute also to the analysis of knowledge and technology transfer via university-industry linkages [9]. Governments worldwide are calling for closer interaction between universities and industry based on the rationale that such interaction is instrumental for fostering technological development and economic achievement [7] and strengthens the co-evolution of scientific and commercial opportunities [29]. At the same time, sceptics point to the possible negative impact of universities’ involvement in technology transfer for the production and advancement of scientific knowledge [19, 21]. The evidence on whether these two activities - conducting research and engaging in knowledge transfer - conflict or are complementary is not conclusive. Our study suggests that scientists who are active in both long-term curiosity driven research and more applied, contract-based research, are more likely to engage in knowledge transfer activities through consulting.

Second, our paper has some practical implications. On the one hand, our findings suggest that to achieve informal knowledge transfer, policy makers should try to guarantee continuous, non-negligible amounts of contract and competitive funding for research. The idea that knowledge and technology transfer requires direct interventions and incentives is not completely supported by our findings, which show that consulting is the predominant mode of university-industry interaction, across all fields of science. This suggests that there is no need for policy interventions to foster consulting activities and that attention should be directed, instead, to ensuring continuing knowledge generation and diffusion activities. This finding supports the general message in Marrocu et al.'s and Borras and Edquist's papers in this Special Issue, that policy must be designed to promote synergies between investments in knowledge diffusion and absorption and investments in R&D for new ideas.

On the other hand, the negative influence of international competitive funding on consulting activity could be counterbalanced and eventually reversed by injections of funding from a variety of other sources. This complementary effect between contract research and international competitive funding calls for policy initiatives that favour the interplay among a mix of sources of funding for research, in order to benefit the generation of knowledge as well as its transfer to external partners.

We tried in the analysis to control for some effects that might hide omitted variable bias driven by unobserved heterogeneity and reverse causality, but lack of a purely experimental setting allowing conclusive analysis, suggests some caution in the interpretation of our results.[13] To our knowledge, this study is one of the first

[13] We are very grateful to an anonymous referee for pointing this out.

empirical contributions to address the impact of different types of research funding (contract and competitive) on consulting. Thus, we believe it will be the motivation for future research and more empirical analysis, including a broader range of individual attributes, to validate (or refute) the results obtained from this study.

References

1. Agrawal, A. & Henderson, R. (2002), 'Putting Patents in Context: Exploring Knowledge Transfer from MIT', *Management Science* 48(1), 44--60.

2. Blundell, R.; Griffith, R. & Van Reenen, J. (1995), 'Dynamic Count Data Models of Technological Innovation', *The Economic Journal* 105, 333-344.

3. Bozeman, B. and M. Gaughan (2007). “Impacts of grants and contracts on academic researcher’s interactions with industry”. *Research Policy* 36: 694-707.

4. Bruneel, J., P. D’Este and A. Salter (2010). “Investigating the factors that diminish the barriers to university-industry collaboration”. *Research Policy* 39 (7): 858-868.

5. D'Este, P. & Patel, P. (2007), 'University–industry linkages in the UK: What are the factors underlying the variety of interactions with industry?', *Research Policy* 36(9), 1295-1313.

6. D’Este, P. and M. Perkmann (2011). “Why do academics engage with industry? The entrepreneurial university and individual motivations”. *Journal of Technology Transfer* 36(3): 316-339.

7. Dutrenit, G. & Arza, V. (2010), ‘Channels and benefits of interactions between public research organisations and industry: comparing four Latin American countries’, *Science and Public Policy* 37 (7), 541-553.

8. Gallessich, J. (1985). “Toward a meta-theory of consultation”. *The Counseling Psychologist* 13 (3): 336-354.

9. Gander, J. (1986), 'The economics of university-industry research linkages', *Technological Forecasting and Social Change* 29(1), 33-49.

10. Geuna, A. (2001). “The changing rationale for European university research funding: Are there negative unintended consequences?”. *Journal of Economic Issues* 35 (3): 607-632.

11. Goldfarb, B. (2008). “The effect of government contracting on academic research: Does the source of funding affect scientific output?”. *Research Policy* 37: 41-58.

12. Grimaldi, R.; Kenney, M.; Siegel, D. & Wright, M. (2011), '30 years after Bayh–Dole: Reassessing academic entrepreneurship', *Research Policy* 40(8), 1045-1057.

13. Gulbrandsen, M. & Smeby, J. C. (2005), 'Industry Funding and University Professors' Research Performance', *Research Policy* 34(6), 932-950.

14. Hall, B. (1993), 'The stock market's valuation of R&D investment during the 1980's', *The American Economic Review* 83(2), 259-264.

15. Hausman, J. & Taylor, W. (1981), 'Panel data and unobservable individual effects', *Econometrica: Journal of the Econometric Society*, 1377-1398.

16. Hottenrott, H. & Thorwarth, S. (2011), 'Industry funding of university research and scientific productivity', *Kyklos* 64(4), 534-555.

17. Jacobson, N., D. Butterill and P. Goering (2005). “Consulting as a strategy for knowledge transfer”. *The Milbank Quarterly* 82 (2): 299-321.

18. Jensen, R.; Thursby, J. & Thursby, M. (2010), 'University-Industry Spillovers, Government Funding, and Industrial Consulting', NBER Working Papers n. 15732.

19. Krimsky, K. (2003). Science in the private interest: has the lure of profits corrupted the virtue of biomedical research? Rowman & Littlefield, Lanham.

20. Landry, R., M.Saïhi, N. Amara and M. Ouimet (2010). “Evidence of how academics manage their portfolio of knowledge transfer activities”. *Research Policy* 39(10): 1387–1403

21. Larsen, M. T. (2011), 'The implications of academic enterprise for public science: An overview of the empirical evidence', Research Policy 40(1), 6--19.

22. Muscio, A. (2010), 'What drives the university use of technology transfer offices? Evidence from Italy', *The Journal of Technology Transfer* 35(2), 181-202.

23. Muscio, A.; Quaglione, D. & Vallanti, G. (2012), 'Does government funding complement or substitute private research funding to universities?', *Research Policy*, 42(1), pp. 63-75.

24. Perkmann, M.; Tartari, V.; McKelvey, M.; Autio, E.; Brostrцm, A.; D’Este, P.; Fini, R.; Geuna, A.; Grimaldi, R.; Hughes, A. & others (2012), 'Academic engagement and commercialisation: A review of the literature on university–industry relations', *Research Policy*, in press.

25. Perkmann, M. & Walsh, K. (2007), 'University–industry relationships and open innovation: Towards a research agenda', *International Journal of Management Reviews* 9(4), 259--280.

26. Perkmann, M. and K. Walsh (2008). “Engaging the scholar: Three types of academic consulting and their impact on universities and industry”. *Research Policy* 37: 1884-1891.

27. Phillips, F. (1998), 'University-industry partnerships in management research', *Technological Forecasting and Social Change* 57(3), 257-260.

28. Rentocchini, F.; Manjarrés-Henriquez, L.; D'Este, P. & Grimaldi, R. (2011), 'The effect of academic consulting on research performance: evidence from five Spanish universities' INGENIO (CSIC-UPV) Working Papers Series 2011/3.

29. Rosenberg, N. and Nelson, R.R. (1994), ‘American universities and technical advance in industry’, *Research Policy* 23, 323-348.

30. UNESCO (1978). Recommendation Concerning the International Standardization of Statistics on Science and Technology. Paris: UNESCO.

31. Vedovello, C. (1998), 'Firms’ R&D activity and intensity and the university–enterprise partnerships', *Technological forecasting and social change* 58(3), 215-226.

Table 1: Proportion of active researchers who obtained extramural budget over the period 1999-2004 by field of science

	Consultancy %	Contract R&D %	National Public R&D %	International Public R&D %	N
Agricultural, Biological and Medical Sciences	44.76	33.14	73.17	9.00	697
Social Sciences	45.98	38.84	52.00	5.60	448
Humanities	35.12	18.84	65.58	3.25	430
Mathematics and Physics	32.24	24.28	71.84	7.75	490
Engineering and Technology	70.26	33.64	48.14	7.62	538
Total	46.29	30.19	62.85	6.90	2603

Table 2: Amount of funding per contract by field of science

	Consultancy €	Contract R&D €	National Public R&D €	International Public R&D €
Agricultural, Biological and Medical Sciences	6170	21659	34764	106186
Social Sciences	7878	12889	16286	60392
Humanities	6591	21281	14199	65670
Mathematics and Physics	5576	23699	33374	82076
Engineering and Technology	6965	22016	32898	147173
Total	6686	20070	27993	100950

Table 3: Correlation matrix

	VConsulting	*VContract*	*VCompetNat*	*VCompetInt*	*Exp*
VConsulting	1				
VContract	0.16	1.00			
VCompetNat	0.02	0.18	1.00		
VCompetInt	0.05	0.18	0.20	1.00	
Exp	0.05	0.13	0.23	0.09	1.00
ResAb	-0.02	0.06	0.34	0.10	0.25

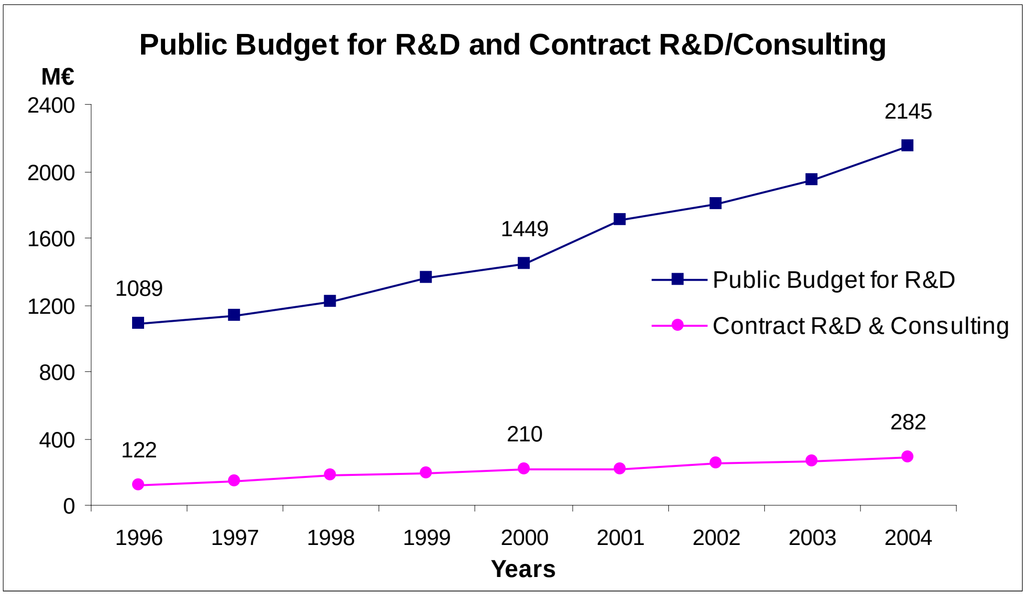
Table 4: Results of the econometric estimates of the relationship between multiple sources of research funding and the amount of consulting activities

	(1)	(2)	(3)	(4)
	Within Estimator	Hausman-Taylor Fixed Effects	Hausman-Taylor Fixed Effects	Hausman-Taylor Fixed Effects
VContract	0.03**	0.03**	0.07***	0.04***
	(0.01)	(0.01)	(0.01)	(0.01)
VCompetNat	-0.01	-0.01	0.01	-0.00
	(0.01)	(0.01)	(0.01)	(0.01)
VCompetInt	-0.04**	-0.04**	-0.03	-0.06**
	(0.02)	(0.02)	(0.02)	(0.03)
ResAb	-	-0.35***	-0.39***	-0.37***
		(0.12)	(0.12)	(0.12)
Exp	-	0.12***	0.11***	0.11***
		(0.03)	(0.03)	(0.03)
VContractXVCompetNat	-	-	0.00	-
			(0.00)	
VContractXVCompetInt	-	-	-	0.01***
				(0.00)
Field Dummies[$]				
Social Sciences	-	0.07	0.08	0.07
		(0.13)	(0.13)	(0.13)
Humanities	-	-0.32**	-0.25*	-0.30**
		(0.13)	(0.13)	(0.13)
Mathematics and Physics	-	-0.41***	-0.38***	-0.40***
		(0.13)	(0.13)	(0.13)
Engineering and Technology	-	0.36***	0.34**	0.35**
		(0.14)	(0.14)	(0.14)
Year Dummies	Inc.	Inc.	Inc.	Inc.
Position Dummies	-	Inc.	Inc.	Inc.
University Dummies	-	Inc.	Inc.	Inc.
Field Dummies	-	Inc.	Inc.	Inc.
Constant	1.35***	1.34***	1.25***	1.00***
	(0.07)	(0.19)	(0.19)	(0.19)
F-test	7.04***			
Wald χ^2		178.34(19)***	235.93(20)***	195.59(20)***
F-tests of joint significance				
Joint significance of Year Dummies	6.44***	25.75***	11.28**	19.36***
Joint significance of Position Dummies		13.27***	8.76**	11.21***
Joint significance of University Dummies		51.69***	51.24***	51.78***
Joint significance of Field Dummies		39.63***	33.36***	36.63***
No of observations	13015	13015	13015	13015
No of groups	2603	2603	2603	2603

[$] Reference Category: Agricultural, Biological and Agrarian Sciences

* p<0.10, ** p<0.05, *** p<0.01; Robust standard errors and degrees of freedom are in parentheses.

Figure 1: Overall trend of the volume of external funding for research in Spain (1996-2004)



Note: Public Budget for R&D refers to total expenditures on R&D supported by public funding, in current monetary terms (http://sise.fecyt.es). Contract R&D and consulting refers to total revenue from contractual agreements via R&D contracts or consulting activities, obtained by universities, in current monetary terms (Encuestra RedOTRI: .www.redotriunivesridades.net).

Figure 2: The moderating role of contract research on on the relationship between internatinoal competive funding and consulting