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University-Industry Relations And Academic Research: Coexistence Or Something Else[1]

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Abstract

In this article we analyse whether university-industry relations (UIR) work to inhibit university researchers' scientific productivity. We find that UIR exercise a positive effect on university scientific productivity when they are based on the development of activities with high scientific content, but only up to certain level. Also, we find that researchers that combine research and UIR activities obtain higher funding from competitive public sources than those that only engage in research. In addition, their average scientific productivity is higher and they achieve higher status within the institution than those members of faculty that concentrate only on research.

Palabras claves: University research, university- industrial relations, scientific productivity.

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1. Introduction

Several authors have highlighted that since the mid 1980s radical changes have been taking place in the production of knowledge and in university institutions themselves. **Etzkowitz (1990)** equates these transformations to the emergency of a "second academic revolution" which, like the first, has resulted in the adoption by universities of a new mission, complementing the traditional activities of teaching and research. This third mission embraces all those activities related to the generation, use, application and exploitation outside academic environments, of the knowledge and other capabilities available to universities (**Molas-Gallart et al. 2002**).

This new third mission seeks to develop new ways for universities to contribute to economic and social development through a closer linking with the different agents in their environment. As a result, previously isolated institutional spheres have become intertwined, giving rise to entirely new types of science and university that bring academic, economic and wider social purposes together in a way that is compatible **(Etzkowitz 2003; Nowotny et al. 2001)**. As a result of this dynamic new structures are appearing within universities (technology transfer offices - TTOs) and hybrid structures are being created with other agents (science and technology – S&T parks, joint institutes), which transcend the institutional frontier of the university and promote the economic exploitation of its knowledge **(Tuunainen 2005).** Thus, a new type of university has emerged, for which there is no agreement in the literature on a single name; they are sometimes referred to as “services universities” **(Enros & Farley 1986)**, or “entrepreneurial universities” **(Clark 1996; Smilor et al. 1993)**.

The transformations described above presuppose a change in the traditional values of the university. In this sense, **Lee (1996)** and **Azagra et al. (2006),** pointed to a change in the attitudes of faculty members toward the recognition of UIR as a valid university activity. However, some authors have highlighted the negative effects of this new external orientation of the university on the traditional missions of teaching and research. Teaching, for example, can be affected by an over-emphasis on short-term specific skill needs, as opposed to a broader education **(Martin and Etzkowitz 2000)**.

In research, the development of the third mission can work to penalise the autonomy of the university and to direct the lecturer's research agenda toward activities with potential economic utility. Similarly, some authors have criticized UIR and maintain that they produce a constant friction between the desire of researchers to publish, and the aim of private sponsors to delay publication in the interests of protecting intellectual property **(Dasgupta and David 1994).** However, there is little rigorous systematic evidence that this is occurring and it is an area that requires more empirical research and analysis **(Martin and Etzkowitz 2000).**

It is against this background that this paper sets out to evaluate the effects of UIR on the development of one of the university's traditional missions: research.

A variety of positions are adopted in the literature. Pessimistic approaches see these changes and transformations as a threat to high quality scientific production and the autonomy of researchers **(Florida and Cohen 1999)**. **Rosenberg and Nelson (1994)**, in their study on the US case, conclude that in spite of effective combinations in certain types of research, it is necessary to maintain the division between university and industry. The more optimistic approaches, however, generally point out that UIR can contribute to scientific productivity and some researchers have found a significant relationship between industry financing and scientific performance of professors **(Gulbrandsen and Smeby 2005; Landry et al. 1996**). Finally, the intermediate position suggests that university collaboration with industry can improve professors' scientific productivity, but only up to certain level. **Blumenthal et al. (1996),** based on a survey of 2,052 faculty members in the life sciences, across 50 US universities, show those faculty members that receive more than two-thirds of their research support from industry sources have lower academic productivity that those with less support from industry. **Bonaccorsi et al. (2006)** found similar patterns for the Italian university system and provide empirical evidence of the existence of an inverted-U shape curvilinear relationship between UIR and publication.

In general terms, the central question that emerges is whether the university is the appropriate institution to transfer and to commercialize knowledge, not because this function is incompatible with that of creating knowledge, but because it involves a cost that can be excessive **(Azagra 2004).** In this context we address the following questions:

1. Can the university assume links with the socioeconomic environment (UIR) without penalizing its research activity?

2. What effects do UIR exercise on universities' scientific productivity?

The analysis is carried out taking the University of Valencia, one of the oldest universities in Spain, as a case study. This university is located in the Valencian Community, a region designated as being of low absorptive capacity, based on research and development (R&D) and innovation indicators **(Azagra et al. 2006).**

The remainder of the paper is structured as follows. In section 2 we present the methodological aspects of the empirical study, and describe the data and variables used in the statistical analyses. In section 3 we present the results obtained and section 4 provides the main conclusions from the study.

2. The data and methodology

The empirical study is based on a single case: the University of Valencia (UV). This university was established more than 500 years ago, has around 50,000 enrolled students and more than 3,000 lecturers. Research and teaching activities are mainly in three areas: social sciences and humanities, applied and natural sciences, and medical science.

UV has a strong tradition of basic research. The C&D Foundation 2005 report ranks UV 5th among Spanish universities in terms of number of scientific publications per lecturer, and 4th in terms of public funding received. However, UV does not figure in the top ten universities for amount of private funding per lecturer.

Our study focuses on three aspects: UIR, academic research, and scientific productivity. UIR is analysed in terms of external agents' (firms, public administrations, non-profit organizations, etc.) exploitation of university activities. This extends the traditional definition of UIR, which is usually limited to the development of joint activities with the productive sector, and comes closer to the concept of the "third mission". The analysis of research activities includes number of research projects developed with funding from competitive public sources. Scientific productivity is assessed as the number of articles published in journals indexed in the Thomson Institute for Scientific Information (ISI) database.

The data are analysed at lecturer level. In our study we consider only faculty members who have participated in research projects supported by competitive public funding, or in activities contracted by external agents, during the period 1999-2004. The final sample includes 1,105 professors/lecturers,[3] (in the following we refer to researchers to mean either of these categories).

In order to assess whether involvement in UIR penalizes research activities, we split the sample into three groups:

1. Researchers who have been involved in both research projects and activities contracted by external agents.
2. Researchers who have participated only in activities contracted by external agents.
3. Researchers who have participated only in research projects.

In each of these groups, we analyse the intensity of the research activities and the linking activities. Also, using technical comparison of means we analyse whether there

[3] The data were provided by the Vice Rector of Research, through the TTO of UV. These data are derived from a study funded by the High Consultant Council of R&D of the *Generalitat Valenciana*

are significant differences among these groups with regard to scientific productivity and researchers.

The basic specification used to evaluate the effects of UIR on scientific productivity is:

$$SP = \alpha_0 + (\alpha_1 \log R\&D + \alpha_2 \log TSC + \alpha_3 \log ST + \alpha_4 \log^2 R\&D) + (\alpha_5 \log EP + \alpha_6 \log NP + \alpha_7 \log RP) + (\alpha_9 EXP + \alpha_{10} POS)$$

Scientific productivity (*SP*) is the dependent variable and is measured on an ordinal scale representing the annual average number of articles published by the researcher in journals indexed in the ISI during the period 2003-2004.

UIR are evaluated by considering three types of activities: R&D contracts (*R&D*); technological support and consultancy contracts (*TSC*); and contracts for specific training (S*T*). The database provides information on the number of contracted actions and their value. However, here we only take account of the latter. Thus, the previous variables are measured as value (in Euros) in terms of the funds obtained by the researcher for the period 1999-2004, derived from the three types of activities described above. We applied logarithmic transformation in order to normalise these variables **(McLeay and Trigueiros 1998).**

Both technological support and consultancy, and specific training are activities that are directed to the solving of specific problems whereas R&D contracts involve activities aimed at the generation of knowledge and generally are accompanied by higher levels of funding. However, what all these activities have in common is that they are carried out for the benefit of external agents.

As we have pointed out earlier, the literature provides only preliminary empirical evidence to suggest that UIR can have a positive influence on scientific productivity.

We consider that the effects of UIR on researchers' productivity depend on the type of interaction involved. We would suggest, therefore, that UIR only have a positive effect when they occur through R&D contracts. In the other cases, UIR can inhibit a researcher's scientific productivity.

We also included in the model an additional variable, calculated as the square of the logarithm of the value of R&D contracts ($R\&D^2$), to evaluate whether the effect that the UIR exercises on scientific productivity is positive up to a certain level, as some authors have suggested **(Bonaccorsi et al. 2006; Blumenthal et al. 1996)**.

The econometric model includes three variables related to academic research: regional projects (*RP*); national projects (*NP*); and European projects (*EP*). These variables are measured as the value (in Euros) of the financing received by the researcher, during the period 1999-2004, from competitive public funds in the regional, national and European contexts. We applied logarithmic transformation once again to assure the normality of the variables.

In contrast to activities contracted by external agents, the projects included in this group are directed basically to the creation of new knowledge and are largely defined by the researcher's particular interests. Thus, we can expect the variables *RP, NP* and *EP* to be positively related to the lecturer's scientific productivity.

In the economic literature, scientific productivity has also been explained by a set of variables related to the researcher's personal attributes, including age, gender and position within the university **(Lehman, 1958, 1960; Levin and Stephan, 1991; Carayol and Matt, 2006).** We integrate some of these features in our regression analysis. EXP is a proxy for work experience and is measured as the number of "quinquenios" obtained by the lecturer.[4] The variable POS is related to the lecturer's position and is measured on an ordinal scale that takes account of faculty grading. In Spain, the highest scale corresponds to university professor. As **Carayol and Matt (2006)** suggest, the expected effects of promotion are ambiguous. On the one hand,

[4] The "quinquenio" is the form of recognition obtained after 5 years experience in academia.

since publication is a key requirement for promotion to a higher scale, there are important incentives for increased scientific productivity to achieve promotion, which reduce once the promotion is awarded. However, since promotion implies a significant increase in social status within the academic sphere, researchers occupying higher positions in the university hierarchy may show greater productivity based on their better ability to exploit external and internal resources (status effect).

As we can see from the definition of the variables, scientific outputs relate to the period 2003-2004, while the variables related to UIR and research activities refer to a longer period (1999-2004). This distinction was made to take account of the time gap between research activities and publication of results. Similar techniques are used in some of the existing studies **(Gulbrandsen and Smeby 2005).**

Table 1 presents the variables used in the analysis.

Table 1. Description of the variables

Variable	Description	Scale	Mean	S.D.
Dependent Variable				
SP	Scientific Productivity	Scale ordinal of 0-3 0, if the researcher has not published in any journals in the ISI database in 2003-2004 1, if the average number of articles for 2003-2004 is in the range 1–2.5 2, if the average number of articles for 2003-2004 is in the range 2.5-5 3, if the average number of articles for 2003-2004 is more than 5	1.04	2.45
University-Industry Relations Activities				
R&D	R&D Contracts	Logarithm of the value in Euros (€) of the financing obtained through R&D contracts 1999-2004	1.64	2.16
TSC	Technological support and consultancy	Logarithm of the value in Euros (€) of the financing obtained from TSC contracts 1999-2004.	0.76	1.62
ST	Specific Training	Logarithm of the value in Euros (€) of the financing obtained from training contracts 1999-2004.	0.21	0.89
$(R\&D)^2$	R&D contract to square	Logarithm to square of the value in Euros (€) the financing obtained from R&D contracts 1999-2004	7.34	10.24
Research Activities				
EP	European Projects	Logarithm of value in Euros (€) of European projects 1999-2004	0.36	1.29
NP	National Projects	Logarithm of value in Euros (€) of national projects 1999-2004.	2.36	2.37
RP	Regional Projects	Logarithm of value in Euros (€) of regional projects 1999-2004.	2.01	2.15
Researcher Characteristics				
EXP	Works Experience	Number of "quinquenios" obtained by the professor during their life work: 1"quinquenio" is equal to 5 years of experience	3.6	1.8
POS	lecturer's position within the university	Scale ordinal of 0-4, where 4 is the highest scale and corresponds to university professor	2.72	1.24

3. Results

3.1 UIR and research

Table 2 presents the sample distribution based on the three groups defined in the methodology. Most researchers (46%) are involved only in research; 29% combine research activities with UIR; 25% are involved only in UIR activities. This distribution is consistent with the profile of the university.

Table 2. Sample distribution

Group	Nº Researchers	% of Sample
1. Researchers engaged in both research projects and activities contracted by external agents.	321	29%
2. Researchers that participate only in activities contracted by external agents.	277	25%
3. Researchers that only engage in research projects	508	46%
TOTAL	1106	100%

Figures 1 and 2 show that researchers engaged in both research and UIR activities receive higher average funding than researchers that engage in only one type of activity. The mean value of the R&D contracts, for example, is three times higher for group 1 than group 2. Also, the mean value of research projects (regional, national, European) is almost twice as high for group 1 than for group 3.

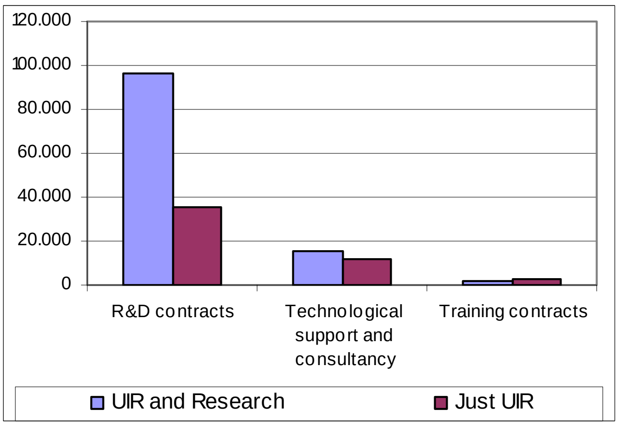

Fig 1.Means values of contracts

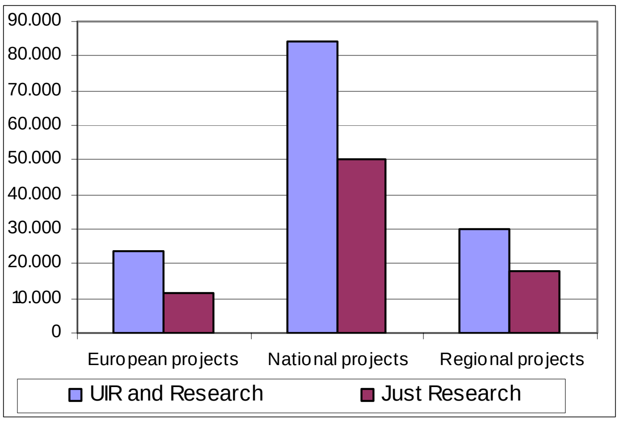

Fig 2. Means values of research projects

Additionally, F-ratios in the ANOVA test and the Sheffé test for multiple comparisons, show statistical significant differences among the three groups of researchers related to scientific productivity. Specifically, group 1 researchers tend to publish more than their colleagues (table 3). Thus, researchers that engage in both research and UIR activities not only receive higher external funding, but also show higher scientific output.

Table 3. Comparison of means of scientific productivity in the different group of researchers

Group	Scientific productivity **ANOVA F-probability 0,000**	
	Mean	Sheffé test: significant differences
1. Researchers engaged in both research projects and activities contracted by external agents.	3.11	(1) and (2), (1) and (3), (2) and (3)
2. Researchers that participate only in activities contracted by external agents.	0.80	
3. Researchers that only engage in research projects	2.14	

This first set of results seems to indicate that faculty members can take on the development of UIR activities without penalising their research activities. In fact, these results suggest that engagement in both types of activities could increase scientific productivity.

In order to determine whether there are significant differences among the different groups in terms of the characteristics of researchers, we carried out statistical comparison of means tests. In this case the null hypotheses tested are the equality of means between the different groups of lecturers for the variables *EXP* and *POS* (table 4).

Table 4. Comparison of means of researcher's characteristic in the different group of researchers

Group	Work experience **ANOVA F-probability 0,0237**		Position **Kurskal Wallis Sig. Asint 0,000**	
	Mean	Sheffé test: significant differences	Mean	Bonferroni test: significant differences
1. Researchers engaged in both research projects and activities contracted by external agents.	4.09	(1) and (2) (1) and (3)	3.06	(1) and (2), (1) and (3), (2) and (3)
2. Researchers that participate only in activities contracted by external agents.	3.27		2.28	
3. Researchers that only engage in research projects	3.49		2.74	

These statistical tests show that position is the characteristic that differs most across the groups. Similar to the results for scientific productivity, researchers that combine research with UIR activities have higher average positions. In the case of work experience the difference is only significant between researchers that engage in both types of activity and those involved only in UIR.

These results indicate that lecturers that participate in research activities as well as UIR activities, not only receive higher funding and have greater scientific production, but also have higher status within the institution. This is in line with **Carayol and Matt's (2006)** findings that a higher position increases recognition in the academic sphere and makes researchers better able to exploit external resources.

3.2 UIR and scientific productivity

To evaluate the effect of UIR on scientific productivity, we estimated the econometric model outlined in the section 2. Due to the ordinal character of the dependent variable (*SP*) we chose ordinal logistical regression as our estimation technique **(McCullangh, 1980; Peterson and Harrel, 1990).**

Table 5 presents the results. The value of the pseudo-R^2 of Nagelkerke is 0.20, which indicates that the model has acceptable prediction power. The Chi-squared values for degrees of freedom corresponding to the model suggest rejection of the null hypothesis that all parameters, except the intersection, are equal to zero at a significance level of 1%.

Table 5. Ordinal logistical regression of the variables that influence in the scientific productivity of the university professors

	Scientific Productivity	
	B	**S.E.**
μ_0	2,85***	0,23
μ_1	4,57***	0,26
μ_2	5,55***	0,28
Researcher's characteristics		
POS	0,46***	0,08
EXP	0,01	0,05
Fundng from external contracts		
Log R&D	0,388***	0,16
LogTSC	-0,001	0,04
Log ST	-0,045	0,08
Log^2 *R&D*	-0,070**	0,03
Funding from public competitions		
Log EP	0,15***	0,05
Log NP	0,22***	0,03
Log RP	0,16***	0,03
Pseudo- R^2 Nagelkerke 0,20		
-2 log likelihood 1855.634		
***Significance at 1%, **Significance at 5%		

In terms of researchers' characteristics, we find that position in the university has a significant and positive effect on scientific production, while experience has no effect. These results reflect the patterns found in previous studies and highlight that the effect of the variable experience is weakened when aspects related to the position or recognition in the institution are included in the analysis **(Carayol and Matt, 2006; Knorr et al. 1979; Zuckerman and Merton, 1972).**

On the other hand, the parameters calculated in the regression model show significant and positive relationship between research financed by competitive funding, and the researcher's scientific productivity. Also, the estimated coefficients show that national projects have a higher positive effect on scientific production than regional or European projects.

The results also indicate that the effects of UIR depend on the instruments used to establish the relationship. When UIR is based on low scientific-technological content activities, this does not increase scientific productivity and may even affect it negatively.[5] Thus, too much emphasis on the development of routine activities for industry can detract from the "entrepreneurial university" model and render the institution simply a "consulting university" with poor scientific indicators **(Geuna, 1999; Arocena and Sutz, 2005)**.

In contrast, when the linking is accomplished through R&D contracts UIR have a positive and significant effect on scientific productivity. A possible explanation for this phenomenon is that R&D contracts are the only joint activities that generate new knowledge. However, it should be remembered that these types of contracts invariably include confidentiality clauses, which hinder the diffusion of results. Consequently, the high significance of this variable in our regression model could be due to indirect effects, derived from the higher level of resources obtained and the learning that is embedded in these types of activities. Nevertheless, these results reinforce that UIR is not an activity that penalises university research *per-se*.

[5] Although the variable TSC and ST were not significant, their coefficients suggest a possible negative effect on the scientific productivity

On the other hand, the coefficient estimated for the variable *log²_I&D* is significant and negative, indicating that the financing from R&D contracts favours scientific productivity only up to certain level, after which it has a negative effect. In order to make a preliminary determination of this tipping level we defined a new variable calculated as the percentage from R&D contracts in the researcher's total budget. This variable is measured on an ordinal scale and is linked to scientific productivity through the following econometric specification:

$$SP = \alpha_0 + \alpha_1 EXP + \alpha_2 POS + \alpha_3 R\,\&\,D\%$$

In this model we included researcher characteristics as an additional explanatory variable in order to avoid problems of collinearity with the other variables related to funding. The results are presented in the table 6.

Table 6. Ordinal logistical regression

	Scientific Productivity	
	B	**S.E.**
μ_0	2,082***	0,231
μ_1	3,705***	0,249
μ_2	4,654***	0,269
Researcher's characteristics		
POS	0,556***	0,079
EXP	0,051	0,046
Percentage of finance from contracts (R&D)		
100%	-0,653***	0,255
75%-100%	-0,217	0,328
55%-75%	-0,200	0,290
35%-55%	0,116	0,265
15%-35%	0,301	0,256
0%-15%	1,202***	0,218
0%		
P-seudo R^2 Nagelkerke	0,16	
-2 log likelihood	569.778	

***Significance at 1%, **Significance at 5%

The parameters estimated in the new regression model show that the funding derived from R&D contracts has a positive and significant effect on scientific production only when it constitutes less than 15% of the researcher's total budget. Where funding from R&D contracts with external agents is above than 55%, scientific productivity tends to diminish. These results provide complementary empirical evidence to the findings from previous studies that point to the existence of an inverted U–shaped relationship between industry funding and scientific production **(Blumenthal et al. 1996; Bonaccorsi et al. 2006).**

4. Conclusions

The adoption by universities of the so called "third mission" has generated concerns with regard to the viability of combining knowledge transfer activities with the traditional university missions of teaching and research. In this paper we have analysed whether relations between the university and its socioeconomic environment penalise research activities and inhibit the scientific production of university faculty in a long established generalist university.

The results obtained do not provide evidence that engagement in UIR as an additional university activity, negatively influences research performance. On the contrary, the analyses indicate that researchers that combine research and UIR activities obtain higher levels of competitive public funding than those that engage only in research that is similarly financed. In addition, researchers that combine both activity types have higher average scientific productivity.

However, this is not to say that more engagement in UIR will increase scientific productivity. UIR only exercise a positive effect when they are based on activities with a high scientific-technological content (R&D contracts), and only up to certain level. Our estimates indicate that R&D contracts have a positive effect on scientific productivity only when the funds obtained through these activities do not exceed 15% of the researcher's total funding. These results are preliminary and to determine more definitely and understand better the level at which links with external agents contribute to scientific productivity requires more investigation.

Among researcher's individual characteristics, we find that only position within the university has a positive effect on scientific productivity and that the effect is greater for the group of researchers involved in both research and UIR. This suggests that in our context, researchers taking on the activities of the university's second and third missions jointly, are those with greater status within UV. This aspect has important implications if we also take into account that the opinions of these senior faculties are usually decisive in defining the direction of the institution.

Future research in this area could include similar analyses but with a broader sample and data on other types of universities, and among different scientific disciplines.

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