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Conducting prosocial research: cognitive diversity, research excellence and awareness of the social impact of research

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Abstract

We propose the concept of pro-social research as reflecting the adoption of attitudes and conducts that place social relevance as a critical goal of research. We argue that pro-social conducts represent a behavioural antecedent of the actual engagement of scientists in knowledge transfer activities. We investigate the impact that different cognitive aspects have on the development of pro-social research behaviour. In particular, we examine if certain types of research skills (i.e. cognitive diversity and research excellence) have a positive impact in shaping a pro-social research behaviour and, more critically, if they act as substitutes for prior experience in knowledge transfer activities. The main source of data comes from a large scale survey conducted on all scientists at the Spanish Council for Scientific Research (CSIC).

Jelcodes:O31,O32

CONDUCTING PROSOCIAL RESEARCH: COGNITIVE DIVERSITY, RESEARCH EXCELLENCE AND AWARENESS OF THE SOCIAL IMPACT OF RESEARCH

INTRODUCTION

The growing emphasis to encourage university-business collaborations has been recently matched by an interest in the micro-foundations of scientists' engagement in knowledge and technology transfer activities (Rothaermel et al., 2007). This interest partly stems from the important challenges faced by academic scientists when planning to work at the interface between academic and business environments, having to reconcile different (often conflicting) norms, priorities and incentives (Jain, George, & Maltarich, 2009a; Philpott, Dooley, O'Reilly, & Lupton, 2011; Tartari & Breschi, 2012). Several studies have pointed out the importance of cognitive and motivational factors underlying academic entrepreneurship (Fini, Grimaldi, Marzocchi, & Sobrero, 2012; Goethner, Obschonka, Silbereisen, & Cantner, 2012). Firm creation is, however, a very specific and exceptional channel of knowledge and technology transfer associated to university-business interactions. We know comparatively less about the extent to which cognitive and motivational factors shape the adoption of a research mode that embraces knowledge exchange and co-production of knowledge with non-academic actors. This paper aims to contribute to this subject by investigating the antecedents of scientists' engagement in knowledge transfer activities.

First, we propose the concept of prosocial research behaviour as a reflection of the adoption of attitudes and conducts that place social relevance as a critical goal of research. We argue that prosocial conducts represent a behavioural antecedent of the actual engagement of scientists in knowledge transfer activities. Second, we investigate the impact that different cognitive aspects have on the development of prosocial research behaviour, once controlling for motivational aspects. In particular, we examine if certain types of research skills (i.e. cognitive diversity and research excellence) have a positive impact in shaping a prosocial research behaviour and, more critically, if they act as substitutes for prior experience in knowledge transfer activities.

Our study of 1295 scientific researchers, representative of the whole population of scientists at the Spanish Council for Scientific Research - the largest public research organisation in Spain – provides the context to test our hypothesis about the relationship between cognitive skills and prosocial research behaviour. We begin by integrating technology transfer and organisational psychology literatures to substantiate our hypotheses. We then describe the methodology, test our hypotheses, and present the results. We end the paper with a discussion of the results and directions for future research.

BACKGROUND AND HYPOTHESES

Prosocial Organizational Behaviours

Research on prosocial behaviour has received considerable attention among organizational behaviour scholars (e.g.: De Dreu & Nauta, 2009; Grant & Sumanth, 2009; Grant, 2007; McNeely & Meglino, 1994). Brief & Motowidlo (1986) conceptualized prosocial behaviour in organizational settings such as "*behaviour which is (a) performed by a member of an organization, (b) directed toward an individual, group, or organization with whom he or she interacts while carrying out his or her organizational role, and (c) performed with the intention of promoting the welfare of the individual, group, or organization toward which it is directed*." (711:1986). Acts such as helping, sharing, donating and cooperating are forms of prosocial behaviour, since these actions share the central notion of intent to benefit others while not formally specified as role requirements. It is well ingrained in organizational behaviour literature that individuals differ in their tendency to engage in prosocial behaviours and in their prosocial values (Audrey, Meglino, & Lester, 1997; Meglino & Korsgaard, 2004). Prosocial behaviour is consistently related to increased levels of commitment and dedication toward ones' job requirements (Grant & Sumanth, 2009; Thompson & Bunderson, 2003), better coordination and cohesion among organizational members (Organ, Podsakoff, & MacKenzie, 2005) as well as higher levels of work-group performance (Puffer, 1987). It is also recognized that coordination costs decline when individuals are more inclined to benefit others through their work. Further, the engagement in prosocial behaviours helps individuals to experience their work as more meaningful, enhancing their feeling of social worth in the workplace (Perry & Hondeghem, 2008).

Given its importance for the organizational functioning, a substantial amount of research has gone into explaining the determinants of prosocial behaviour. Prosocial behaviour is thought to be influenced by a complexity of factors ranging from biological and psychological bases (Buck, 2002) to social and contextual issues (Kerr & MacCoun, 1985). Recent research revealed that, while carrying out their work, individuals define their identities in terms of helping within specific roles (Penner, Dovidio, Piliavin, & Schroeder, 2005). Hence, the particularities of the work itself are likely to exert a considerable effect in the emergence of prosocial identities and prosocial behaviours among individuals. Nevertheless, understanding the particular combination of individual attributes and working features more prone to activate prosocial behaviours still remains an open issue for further research.

The emergence and maintenance of prosocial behaviours is particularly interesting in the context of mission-driven organizations (Grant & Sumanth, 2009), Those organizations refers to those whose purposes transcend economic profit, such as hospitals, government agencies, universities and public research centres (Hammer, 1995) . Indeed, one of the critical goals of mission-driven organizations is to generate a positive contribution towards others' needs. In the section below, we move to the emergence of prosocial behaviours within the context of a public research organization.

Prosocial Research Behaviour as a Precursor to Engagement in Knowledge Transfer

Our focus in on the causes and effects of the emergence of a prosocial research behaviour among scientists, and how this particular behaviour may be correlated to a higher propensity to engage in knowledge transfer activities. Knowledge and technology transfer involves a wide range of activities aimed to exchange knowledge with non-academic actors (Tartari & Breschi, 2012). A number of academic studies have recognized that knowledge and technology transfer among the spheres of industry, academia and state is crucial to boost economic growth and improve social welfare. Policymakers are increasingly supporting the adoption of knowledge transfer practices among research scientists (Mowery, 2004). Providing commercialization incentives and exchanging university-industry personnel are examples of initiatives devoted to stimulate the transfer of knowledge between research scientists and non-academic agents.

While, from a policymakers' standpoint, the engagement of research scientists in knowledge transfer activities seems to be highly desirable, evidence suggest that research scientists differ in their willingness to adapt to the new rules of the game. Individual scientists are motivated by a range of personal and institutional incentives that determine their involvement in knowledge transfer activities (Bercovitz & Feldman, 2008). Because of the particular set of norms and incentives in the academic environment, the transit from academic research to engagement in knowledge transfer activities is non-trivial for most researchers (Jain et al., 2009; Philpott et al., 2011; Tartari & Breschi, 2012). This raises the possibility that psychological processes related to the perceived usefulness of the scientists' research activities may foster employees to participate in knowledge transfer activities. In this sense, the feelings of task significance and social worth associated to the undertaking of prosocial behaviours (Grant et al.,

2007) may be helpful to explain why some researchers are more willing to engage in knowledge transfer activities while others not.

Taking research scientists as our context of study, we propose that prosocial research behaviour may play an important role in guiding researchers towards considering their research activities as socially relevant and thus, to prompt them towards the engagement in knowledge transfer activities. Specifically, we conceive prosocial research behaviours as these conducts that place social relevance as a primary goal of research. We argue that this social relevance may be reflected in three different but highly related conducts that may be performed by research scientists. First, an explicit awareness and recognition that one's research results might have a potential social impact in other people or groups (Shane & Venkataraman, 2000). When individuals perceive that their work exerts a positive impact in others, they tend to be more willing to go above and beyond their call of duty (Grant, 2008; McNeely & Meglino, 1994), perform extra-role behaviours, show higher commitment and dedication (Thompson & Bunderson, 2003) and be less emotionally exhausted (Grant & Sonnentag, 2010). Second, an identification of the potential users of research findings (Gibbons et al., 1994; Stokes, 1997). Third, an identification of the intermediate agents that may serve to channel the social impact of research (Jain et al., 2009). We therefore propose that a prosocial research behaviour, conceived as a precursor of engagement in knowledge transfer activities, is comprised by these three conducts.

Fundamental to our argument is the claim that prosocial research behaviour, as conceived above, enhances the likelihood of academic researchers to engage in knowledge transfer activities. Prosocial research behaviour means that researchers are infused with an explicit interest in benefiting others through their research findings, even through actions that are not prescribed in job duties (McNeely & Meglino, 1994). Therefore, the participation in knowledge transfer activities may enable them to channel this interest towards delivering knowledge that is not only valuable for academics, but also useful to other external agents. Prosocial identities are well-ingrained in the academic entrepreneurship and technology transfer literatures, with studies that propose that scientists who have an aspiration to achieve a broader societal impact from their research and have a strong awareness about the implications of their research on the well-being of others, are more willing to embrace a favourable attitude towards knowledge transfer activities (Gibbons et al., 1994; Jain et al., 2009; Lam, 2011; Weijden et al., 2012). According to these studies, adopting attitudes and conducts that place social relevance as a critical goal of research are crucial to reconcile the conflicting priorities and incentives faced by academic scientists when planning to work at the interface between academic and business environments.

Further, previous research has consistently documented that individuals with other-focused outcome goals tend to be more committed and dedicated towards these goals (Thompson & Bunderson, 2003), are less emotionally exhausted in this endeavour (Grant & Sonnentag, 2010) and maintain higher levels of motivation in the workplace (Grant et al., 2007). Overall, then, these arguments lead us to suggest that the adoption of prosocial attitudes and behaviours, within the context of academic research might be seen as an immediate predictor of an actual participation in a broad range of knowledge transfer activities, compared to researchers who lack the motivation to generate a positive social impact from their research.

Antecedents of Prosocial Research Behaviours

We extend the knowledge transfer literature by examining the factors that contribute to the configuration of prosocial research behaviour, as characterised above. More specifically, we are interested in identifying those skills that are conducive to prosocial research behaviours among scientists, paying a particular attention to those scientists who exhibit no (or very little) prior experience in knowledge transfer activities. Drawing on the academic entrepreneurship and organizational behaviour literature, we examine the role of prior experience and anticipate two potentially relevant skills to predict the emergence of prosocial research behaviour: research excellence and cognitive diversity.

First, we can reasonably expect that experience matters in shaping prosocial research behaviour. Those scientists with previous experience as entrepreneurs, or in knowledge transfer activities more broadly, are likely to have developed the mindsets and skills necessary to gain a sense of perceived feasibility towards the engagement in knowledge transfer activities (Goethner et al., 2012; Hoye & Pries, 2009; Krueger JR, Reilly, & Carsrud, 2000; Landry, Amara, & Rherrad, 2006). Further, previous knowledge transfer activities mean that scientists have been in contact with potential beneficiaries of their academic work. Because existing research emphasizes that contact with beneficiaries is an important driver for the development of prosocial attitudes and behaviours, (Goldman & Fordyce, 1983. Grant et al., 2007; Grant, 2007), we propose that having previous knowledge transfer experience can increase scientists' prosocial research behaviours. From a scientist' perspective, previous contact with potential beneficiaries allows scientists to directly appreciate the potential beneficiaries' demands and give emphasis towards their needs (Brief & Motowidlo, 1986). Organizational research further points that developing interpersonal interactions with potential beneficiaries of one's work is a source of task significance (Grant et al., 2007), which directly enables to experience ones' work as more meaningful (Morgeson & Humphrey, 2006) and increase work persistence and job performance.

Building on this logic, we expect that having previous ties with beneficiaries of one' work should be particularly relevant among scientists to facilitate and inspire prosocial research behaviours. In an institutional work environment with high pressure to perform according to academic metrics (Bercovitz & Feldman, 2008), previous experience in knowledge transfer may fuel the scientists' motivation to go beyond the Mertonian norms of science (Merton, 1979). On average, such scientists will develop a greater concern about the social impact of their subsequent research activities, compared with those scientists with less or no previous knowledge transfer experience. Hence, that should make them more willing to put their best foot forward with the fulfilment of potential non-academic beneficiaries' needs and embrace a broader range of conducts that reflect a stronger awareness about the social impact of their research activities. Accordingly, we put forward the following hypothesis:

H1: Experience in knowledge transfer is positively associated with prosocial research behaviour.

A number of studies indicate that research excellence is likely to substantially affect the scientists' tendency to participate in knowledge transfer activities (Calderini, Franzoni, & Vezzulli, 2007; Link, Siegel, & Bozeman, 2007; Perkmann, King, & Pavelin, 2011). The quantity and quality of academic publications is a recognized indicator of academic reputation. In this sense, previous research indicates that scientists with outstanding research performance may enjoy a particularly high visibility and prestige, exerting a signalling effect on potential users of their findings (Landry et al., 2006; Perkmann et al., 2011). Scientists with high standards of research excellence are considered to embody more valuable human and social capital (Fuller & Rothaermel, 2012). As a consequence of their prominent academic performance, star scientists are able to send credible signals to external actors (Spence, 1973) and thus, will be more likely to orient their research towards the potential non-academic beneficiaries of their research results. Moreover, scientists with an outstanding scientific record may exhibit an enhanced sense of competence and greater confidence in one's ability that may contribute to elicit a favourable attitude towards helping others and interact with potential beneficiaries of their research activities (see Brief & Motowidlo, 1986 and Mowaday et al., 1982). A self-perception of one's helpfulness and competency is significantly important in shaping a positive disposition towards exerting a positive impact in others (Penner. et al., 2005).

While research excellence is likely to predict prosocial research behaviours, this relationship, however, may not be homogeneous across all levels of research excellence. Rather, the relation may exhibit a J-shape if scientists are reluctant to pro-social research behaviour at low and intermediate levels of research excellence. This may happen due to scientists' fears that this type of prosocial behaviour may endanger their efforts to achieve research priority and higher recognition among peers, as it may shift the focus of the dissemination of research findings away from the scientific community, towards non-academic stakeholders (Stephan, 2010; Weijden et al., 2012). While these negative effects might be irrelevant once a scientist has reached high status and recognition among peers, they may constitute an important factor in shaping behaviour among scientists who have not yet made their mark in the scientific community. Building on this discussion, we put forward the following two related hypotheses:

H2a: Research excellence is positively associated with prosocial research behaviour.

H2b: There is a curvilinear J-shape relationship between research excellence and prosocial research behaviour such that researchers exhibit lower prosocial research behaviour at low and intermediate levels of research excellence.

Third, we hypothesise that cognitive diversity is positively linked to conducting prosocial research. Cognitive diversity refers to the cognitive spam of a research scientist, conceptualized as the diversity and balance of the areas of research in which the scientist works. Entrepreneurship research suggests that scientists with a broader expertise across fields of science are likely to conduct more distant search and to develop gatekeeper roles (within and outside the academic world), which should enhance identification of new lines of inquiry and awareness of social relevance and commercial opportunities of their research (Fleming, Mingo, & Chen, 2007; D'Este et al., 2012). As researchers are equipped with higher cognitive diversity, they are more likely to integrate the potential users' needs into their research agendas and therefore, show higher levels of prosocial research behaviour. Being capable to integrate distant bodies of knowledge allows researchers to conduct research more useful for practitioners (Grant & Berry, 2011; Mohrman, Gibson, & Jr., 2001).

This relationship may exhibit an inverted U-shape given that high levels of cognitive diversity may exert a negative impact on scientists' ability to conduct prosocial research, as a result of the increasing challenges for knowledge integration when broader and distant bodies of knowledge are dealt with (Rafols, 2007; Yegros et al., 2011). Drawing on this discussion, we put forward the following two related hypotheses:

H3a: Cognitive diversity is positively associated with prosocial research behaviour.

H3b: This relationship may exhibit an inverted U-shape if increasing levels of cognitive diversity have a decreasing effect on scientists' prosocial research behaviour.

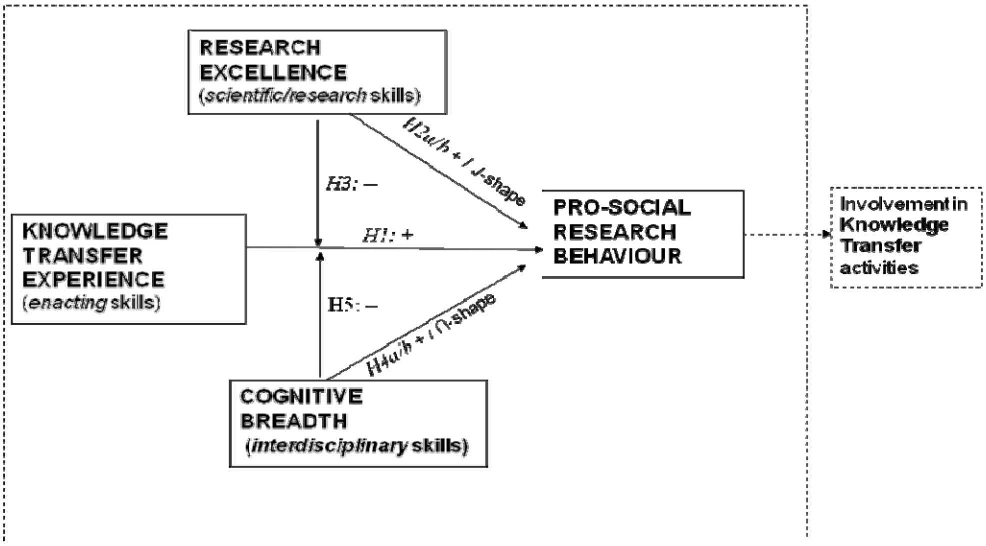
Finally, we also hypothesise that both research excellence and cognitive diversity are likely to act as substitutes for knowledge transfer experience, as we expect that these two skills should play a stronger role to elicit prosocial research behaviour among scientists with no (or little) knowledge transfer experience, compared to those who have already developed the required enacting skills for knowledge transfer. We expect that high scientific visibility and self-confidence about one's research abilities would compensate for the absence of previous knowledge transfer experience, contributing to eliciting a prosocial attitude and conduct particularly among those with little or no prior knowledge transfer experience. Similarly, we expect that cognitive diversity would have a particularly stronger role in the formation of a prosocial research behaviour among those who have no prior knowledge transfer experience, as compared to those scientists who have already built a well-established pattern of interaction with non-academic actors. We therefore put forward the following two related hypotheses:

H4a: Research excellence has a higher impact on prosocial research behaviour at lower levels of experience in knowledge transfer activities.

H4b: Cognitive diversity has a higher impact on prosocial research behaviour at lower levels of experience in knowledge transfer activities.

Figure 1 below provides a picture of the conceptual model and illustrates the hypotheses discussed in this Section.

Figure 1. ***Theoretical Model***



METHOD

Data and Sample

The main source of the data used in this study comes from a large scale survey conducted on all (tenured) scientists at the Spanish Council for Scientific Research (CSIC) - the main public research organisation in Spain. The sample frame consisted of 3199 CSIC scientists, to whom we sent an invitation to participate in the on-line survey. CSIC scientists cover all fields of science, such as Biomedical, Physics, Chemistry, Engineering and Social Science and Humanities (see Table 1, for further details). The survey was conducted between April and May 2011. We reached a 40% response rate, with 1295 valid responses. These responses were representative of the original population of CSIC scientists in terms of age, gender and academic rank[1]. However, as shown in Table 1, while response rates are overall similar by fields of science, there are some disciplines that are overrepresented (such as: Agriculture, Chemistry and Food Science & Technology) while Social Sciences and Humanities is significantly underrepresented.

In addition to the survey, we obtained data from secondary sources: (i) administrative data on socio-demographic characteristics of our population of scientists (i.e. gender, age, academic rank and institute of affiliation); and (ii) bibliometric data from ISI-SCI, to get publication and citation profiles, as well as the scientific field of specialisation, for all the scientists in our study.

[1] In both the target population and our sample of respondents, the average age is 50 and 35% of scientists are women. Regarding professional category, there is a 25% of Professors in the target population, while a 23% in our sample of respondents.

Table 1. ***Response rates by field of science***

Scientific field	Surveyed Population	Valid Responses	Response Rate
Agriculture Sc.& Tech.	365	191	52% *
Biology & Biomedicine	547	199	36%
Chemistry Sc. & Tech.	381	179	47% *
Food Sc. & Tech.	246	119	48% *
Natural Resources	482	190	39%
Physics Sc. & Tech.	424	163	38%
Social Sc. & Humanities	321	90	28% *
Tech. for New Materials	433	164	38%
Total	*3199*	*1295*	*40%*

* The response rates of these four scientific fields significantly differ (chi-square, $p < 0.05$) when compared to the overall response rate for the other fields in our sample.

Measures

Our dependent variable, *Prosocial research behaviour*, is built from the responses to a question that asked scientists to report the frequency (according to a 4-point Likert scale ranging form 'never' to 'regularly') with which they engaged in the following three activities when conducting research projects: (i) identifying potential results from research, (ii) indentifying potential users and (iii) identifying intermediary actors to help transfer the results of their research. We then proceed to compute an average of the responses to these three items, as they were strongly correlated to each other, suggesting that all items of the scale were measuring the same construct and that the scale was consistent (Cronbach alpha of 0.80). Table A1 in the Appendix presents this question as framed in the survey questionnaire. Our measure of prosocial research behaviour follows a bell-shaped, close to normal distribution, with mean, median and mode around 2.5, and a degree of skewness well within the expected values for a normal distribution.[2] This indicates that, overall, scientists engage at intermediate or moderate levels in the three activities we have considered to measure prosocial behaviour, with almost no differences across fields of science.[3] Finally, since our dependent variable corresponds to a scale composed of three items whose values range between 1 and 4, the estimation procedure chosen was a Tobit regression model.

The explanatory variables were measured as follows. We measure *Knowledge Transfer Experience* as the total value (in €s) of R&D contracts, consulting activities and income from licences of intellectual property rights (i.e. patents) in which the scientists were engaged over the period 1999-2010, as reported in the administrative data provided by CSIC. This variable was transformed logarithmically, given its highly asymmetric distribution. While the mean value of income from knowledge transfer activities, for the scientists in our sample, corresponded to 89.6 thousand €, it is worth noting that 57% of the scientists who responded to the survey have not been involved at all in these types of activities (i.e. have no reported income from these activities).[4]

Research Excellence was measured as the average number of citations per paper and year. For each single paper we computed a score for the average received citations per year, from year of publication until 2010, and then we proceed to sum the scores for all the papers corresponding to each scientist and divided this aggregated figure by the total number of publications of the scientist. The resulting measure displayed an asymmetric distribution indicating that few individuals score very high (10% of our sample of scientists have scores of 2.5 or above), while the wide majority fall in the range between 0.1 and 2 average citations per paper and year – there are very few cases (4.5% of scientists)

[2] The distribution departs however from normality due to significant levels of Kurtosis.
[3] There are largely no significant differences in prosocial research behaviour across fields, with the only exceptions of Food Sc. & Tech. and Biology & Biomedicine, which show significantly higher and lower levels compared to other fields, respectively.
[4] Given the high proportion of zeros, this variable was logarithmically transformed after summing 1 to the original values, in order to retain the cases with zero levels of R&D contracts and consulting.

with zero citations to their work. Similar to the previous variable (*Knowledge Transfer Experience*), we also transformed this variable logarithmically.

Our measure of *Cognitive Diversity* is based on the number of subject categories of the journal articles published by each researcher. To build this measure, we use the Shannon entropy index, as this index has the attribute that its scores depend on both the number of subject categories and the degree of balance with which the papers are distributed across the subject categories. For instance, scientists who display an even distribution of publications across subject categories are assigned a higher score compared to scientists whose publications cover a similar range of subject categories but are unevenly distributed – that is, highly concentrated in a few subject categories. The actual expression of this index is presented below:

$CognitiveDiversity = \sum_{i=1}^{i=N} p_i \ln(1/p_i)$, where p_i is the proportion of articles corresponding to the *i*th subject category, and N is the total number of subject categories of the journal articles published by a scientist.[5] The scores of this measure range from zero to 3.5, following a close to normal distribution with a spike in zero, reflecting the significant proportion of scientists whose research is concentrated in one single subject category (i.e. the distribution's mode is zero).

In order to discuss in more detail the type of information provided by this measure, we display some examples drawn from our sample of scientists. For instance, a scientist in our sample exhibits a score for Cognitive Diversity close to the mean as she exhibits a pattern such as the following: 25 publications assigned to 10 different subject categories, including Applied Physics (in 11 publications), Materials Science (5 publications), Physical Chemistry (4), Spectroscopy (1), among other subject categories. The score of this scientist for Cognitive Diversity equals 2.05. A second, contrasting example

[5] Given that an article can be attached to more than one subject category, we considered the total number of subject categories attached to all the articles of a scientist, and used this total (which can be potentially higher than the total number of papers) to compute the proportion of papers attach to each single subject category. Therefore, acknowledging that one paper might be assigned to more than one subject category.

corresponds to a scientist who, despite having the same number of publications as the previous one, has a score of Cognitive diversity equal to zero because all his publications correspond to one single subject category – Astronomy & Astrophysics.

In order to account for other individual attributes that could shape prosocial research behaviour, we also considered some alternative individual-level control variables. First, we considered socio-demographic characteristics of our sample of scientists, such as: the age of researchers (*Age*), gender (whether the researcher is *Male*), and the academic status of scientists (i.e. whether researchers are *Professors*). This information was obtained from the administrative data provided by CSIC. Second, since motivational factors are likely to play an important role in shaping the disposition of scientists to adopt a prosocial research behaviour, we included a number of variables taken from the survey questionnaire, to address motivational features connected to the different types of benefits expected by scientists from the interaction with non-academic agents. These expected benefits included: a) fostering the research agenda of the focal scientist (*Advancing Research*); b) expanding the scientist professional network (*Expanding Network*), and c) increasing the scientist personal income (*Personal Income*). While the first two were computed as three-item scales, the latter one was measured as a single-item scale. For details on the construction of these variables, see Table A1 in the Appendix. Moreover, we also considered two more general types of motivations regarding the main drivers towards engagement in research activities: *Autonomous* and *Controlled* driven motivations. For details on the construction of these variables, see also Table A1 in the Appendix. Third, we also included as controls, information about the volume of articles published per scientist (i.e. log transformation of the total number of papers, *Number Publications*) and the average number of co-authors with whom scientists have published their work (i.e. log transformation of the average number of co-authors, *Average Nº Co-authors*).

Finally, we included a number of controls regarding the environment in which our sample of scientists operates. On one hand, drawing on information from the survey, we built a measure of institutional climate to capture the extent to which scientists considered that their research institutes offered a supportive climate to undertake knowledge transfer activities - *Climate* (see details on this construct in Table A1 in the Appendix). On the other hand, we considered a set of dummy variables to control for the scientific disciplines of our sample of scientists: Agriculture Sc. & Tech.; Biology & Biomedicine; Chemistry Sc. & Tech.; Food Sc. & Tech.; Natural Resources; Physics Sc. & Tech.; Social Sc. & Humanities; Tech. for New Materials. Table 2 shows the descriptive statistics for all the variables used in our analysis (the correlation matrix is displayed in the Appendix (see Table A2).

Table 2. Descriptive statistics

Variables	Mean	S.D.	Median	Min.	Max.	Obs.
1. Prosocial Res. Behaviour	2.516	0.731	2.333	1.000	4.000	1219
2. K. T. Experience (ln)	4.736	5.588	0.000	0.000	15.852	1249
3. Research Excellence*	1.345	1.003	1.142	0.000	9.183	1249
4. Cognitive Diversity	1.676	0.644	1.764	0.000	3.482	1249
5. Advancing Research	1.108	0.522	1.000	0.000	2.000	1237
6. Expanding Network	0.859	0.509	1.000	0.000	2.000	1235
7. Personal Income	0.261	0.552	0.000	0.000	2.000	1239
8. Controlled Motivation	2.843	0.712	3.000	1.000	4.000	1239
9. Autonomous Motivation	3.642	0.475	4.000	1.667	4.000	1248
10. Age	49.826	8.245	49.000	31.000	70.000	1249
11. Gender (Male = 1)	0.649	0.477	1.000	0.000	1.000	1249
12. Professor	0.230	0.421	0.000	0.000	1.000	1249
13. Number Publications*	32.609	32.032	25.000	1.000	286.000	1249
14. Average N^{o}. Co-authors*	7.563	44.225	3.950	0.000	1183.500	1249
15. Climate	2.131	1.782	2.000	0.000	4.000	1249

***** The figures for these three variables correspond to the original values, not to the log transformed ones.

RESULTS

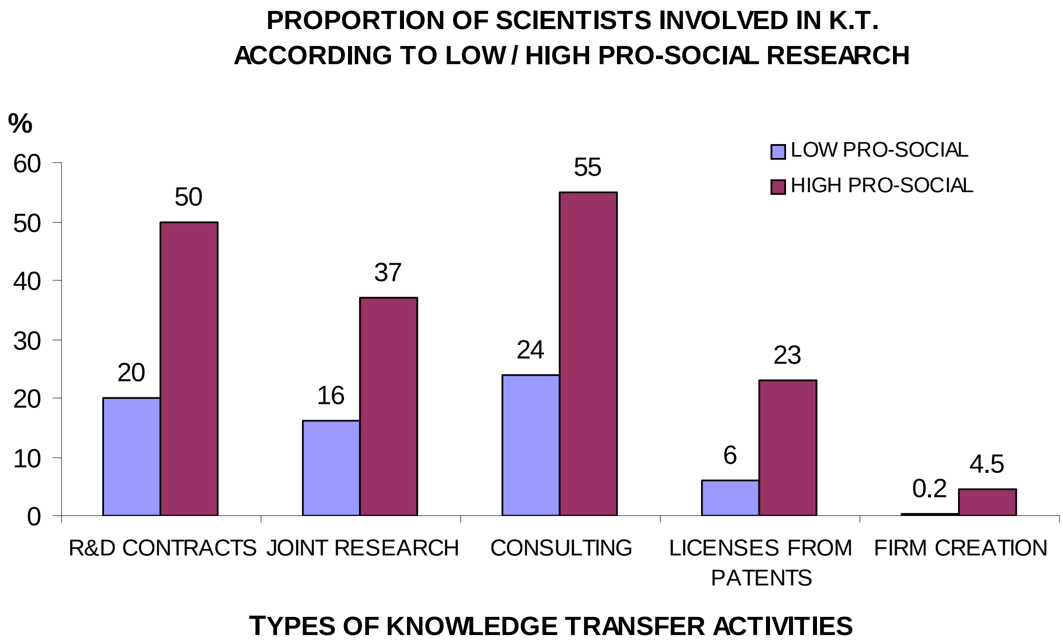
Prosocial Research Behaviour and Engagement in Knowledge Transfer

Drawing upon our conceptual framework, the adoption of prosocial attitudes and behaviours within the context of academic research can be conceived as a precursor of actual engagement in knowledge transfer activities. This is a critical point to justify on a theoretical ground our focus on prosocial research behaviour. In this Section we aim at providing some preliminary evidence showing, from an empirical perspective, the validity of the former premise. While our current analysis does not seek to demonstrate causality, we do believe it is important to investigate whether we observe a systematic connection between the extent to which scientists adopt a prosocial research behaviour and their degree of involvement in knowledge transfer activities.

To that effect, we examined the relationship between conducting prosocial research and engaging in knowledge transfer activities, using the information gathered through the survey questionnaire. We distinguished scientists who scored high in prosocial research behaviour, defined as those with prosocial levels within the highest third-tile (i.e. those 33% of scientists who score highest in prosocial research behaviour), and compared them to scientists whose prosocial scores belonged to the lowest third-tile. We examined the pattern of their responses to a survey question asking whether researchers have been involved, over the three previous years, in any of the following interactions with businesses or technology transfer activities, including: (i) R&D contracts; (ii) joint research activities; (iii) consulting activities; (iv) licenses from patents; and (v) creation of businesses.

As Figure 2 shows, we observe that, no matter what type of knowledge transfer we look at, those scientists scoring high in prosocial research are at least twice as likely to engage in knowledge transfer activities compared to those scoring low. For instance, Figure 2 shows that half the researchers who exhibit high levels of prosocial research behaviour engage in ‘R&D Contracts’ with businesses, compared to a proportion of 20% for researchers scoring low in prosocial research behaviour. This pattern is consistent across all the different type of knowledge transfer activities examined. While this result does not support a claim on causality, it does provide confirmatory evidence about the existence of a strong link between prosocial research and engagement in knowledge transfer activities.

Figure 2. Relationship between prosocial research and knowledge transfer activities



Antecedents of Prosocial Research Behaviour

We run Tobit regression analysis given that our dependent variable, *Prosocial*, takes values ranging between 1 and 4. We investigate the direct impact of prior experience in knowledge transfer, research excellence and cognitive diversity on prosocial research behaviour, and the extent to which cognitive-related skills moderate the relationship between knowledge transfer experience and pro-social research behaviour.[6]

The results are presented in Table 3. First, our results show that, as expected, past experience in knowledge transfer activities is a very strong predictor of prosocial research behaviour. This is a consistent result in all our specifications (see Columns (2) to (6)) and gives support to our first hypothesis, *H1*. Second, Table 3 shows that research excellence plays an important role in explaining prosocial research behaviour, but contrary to our expectations, the linear effect is negative (see Column (2)). Thus, we do not find support to our hypothesis *H2a*, which stated a positive relationship between research excellence and prosocial research behaviour.

However, when examining whether there is a curvilinear relationship between research excellence and prosocial research behaviour, we find a U-shape relationship with pro-social research behaviour. That is, scientists are comparatively reluctant to embrace pro-social research behaviour at intermediate levels of research excellence, while exhibit high levels of pro-social research behaviour for either low or high research excellence. This result is shown in Column (3) where we observe a positive and significant effect of research excellence together with a negative and significant effect for research excellence squared. This result is aligned with our hypothesis *H2b*, which anticipated a curvilinear relationship where the positive effect of research excellence was expected only beyond a certain threshold of excellence. To illustrate this curvilinear relationship between research excellence and prosocial research behaviour, we display this result in Figure 3.

Third, our results also show that cognitive diversity has a positive and significant impact on pro-social research behaviour, which is consistent throughout all the specifications in Table 3. This result is consistent with our hypothesis *H3a*. This result suggests that interdisciplinary research skills (the

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[6] We centred the variables used for the squared and the interaction terms before entering them into the regression analysis, in order to minimise potential mulitcollinearity problems (Aiken & West, 1991)

capacity to integrate multiple bodies of knowledge in research activities) positively contribute to fostering pro-social research behaviour among scientists. However, we did not find any evidence of a curvilinear relationship, as the quadratic term of *Cognitive Diversity* is not statistically significant (see Column (4)); thus, we find no support for our hypothesis *H3b*.

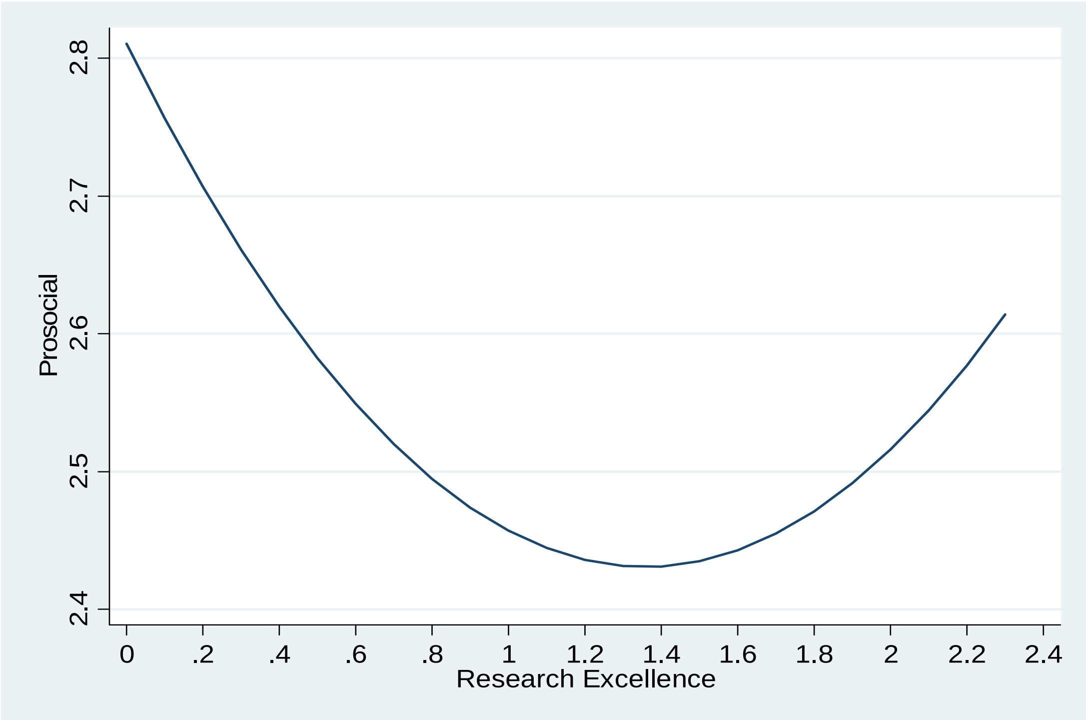
Finally, while our results show that past experience in knowledge transfer activities is a very strong predictor of prosocial research behaviour, we find that cognitive diversity acts as a substitute for experience in knowledge transfer: see the negative sign of the interaction term in Column (6). That is, the impact of cognitive diversity on prosocial research behaviour is stronger for scientists who exhibit little or no previous knowledge transfer experience. This result supports our hypothesis *H4b*. On the contrary, we did not find that research excellence moderated, in any way, the relationship between knowledge transfer experience and prosocial research behaviour: the interaction term between research excellence and knowledge transfer experience is not statistically significant (see Column (5)). Thus, we do not find support for our hypothesis *H4a*.

Table 3. Tobit estimates. Dependent variable: Prosocial Research Behaviour

Variables	(1)	(2)	(3)	(4)	(5)	(6)
K. T. Experience		0.030***	0.029***	0.030***	0.030***	0.031***
		(0.004)	(0.004)	(0.004)	(0.004)	(0.004)
Research Excellence		-0.183***	-0.239***	-0.181***	-0.184***	-0.179***
		(0.069)	(0.076)	(0.069)	(0.069)	(0.069)
Cognitive Diversity		0.089**	0.095**	0.095**	0.089**	0.082**
		(0.042)	(0.042)	(0.044)	(0.042)	(0.042)
Res. Exc. Squared			0.206*			
			(0.110)			
Cognitive Div. Squared				0.019		
				(0.036)		
Res. Exc. * K.T. Exp.					-0.004	
					(0.010)	
Cognitive Div. * K.T. Exp.						-0.012**
						(0.006)
Advancing Research	0.201***	0.204***	0.205***	0.203***	0.204***	0.209***
	(0.047)	(0.051)	(0.051)	(0.051)	(0.051)	(0.051)
Expanding Network	0.278***	0.302***	0.302***	0.303***	0.302***	0.295***
	(0.051)	(0.052)	(0.052)	(0.052)	(0.052)	(0.052)
Personal Income	-0.035	-0.018	-0.019	-0.017	-0.018	-0.018
	(0.042)	(0.042)	(0.042)	(0.042)	(0.042)	(0.042)
Controlled Motivation	0.058*	0.051	0.052	0.049	0.051	0.051
	(0.032)	(0.033)	(0.033)	(0.033)	(0.033)	(0.033)
Autonomous Motivation	-0.078*	-0.064	-0.062	-0.062	-0.064	-0.061
	(0.041)	(0.047)	(0.047)	(0.048)	(0.047)	(0.047)
Age	0.008***	0.003	0.003	0.003	0.003	0.004
	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
Gender (Male = 1)	0.086**	0.067	0.067	0.068	0.067	0.068
	(0.044)	(0.046)	(0.046)	(0.046)	(0.046)	(0.046)
Professor	0.024	0.001	-0.005	-0.001	0.002	0.004
	(0.055)	(0.059)	(0.059)	(0.060)	(0.060)	(0.059)
N^o Publications	-0.006	-0.037	-0.021	-0.037	-0.037	-0.036
	(0.023)	(0.027)	(0.028)	(0.027)	(0.027)	(0.027)
Average N^o. Co-authors	0.013	0.046	0.047	0.045	0.046	0.048
	(0.040)	(0.041)	(0.041)	(0.041)	(0.041)	(0.041)
Climate	0.019*	0.008	0.008	0.008	0.008	0.007
	(0.011)	(0.012)	(0.012)	(0.012)	(0.012)	(0.012)
Intercept	1.428***	1.750***	1.654***	1.736***	1.750***	1.738***
	(0.247)	(0.274)	(0.278)	(0.275)	(0.274)	(0.274)
Scientific Field Dummies	Included	Included	Included	Included	Included	Included
N. Observations	1195	1195	1195	1195	1195	1195
Log Likelihood	-1339.50	-1303.65	-1301.88	-1303.51	-1303.57	-1301.69
LR Chi^2 (d.f.)	201.7***	273. 4***	276.9***	273.7***	273.6***	277.3***
Pseudo R^2 – McKelvey & Zavoina	0.16	0.20	0.21	0.20	0.20	0.21

* $p < 0.10$; ** $p < 0.05$; *** $p < 0.01$. Standard errors in parentheses.

Figure 3. Curvilinear relationship between Research Excellence and Prosocial Research Behaviour



DISCUSSION AND CONCLUSIONS

This study attempts to provide a deeper understanding of the drivers of knowledge and technology transfer engagement among scientists, by bringing to the foreground the concept of prosocial research behaviour. We believe that prior studies have paid little attention to the behavioural antecedents of technology transfer, and in particular, to those conducts that reflect a prosocial awareness about the impact of research. Our study attempts to fill this conceptual gap by focusing on research conducts that reflect a strong awareness about social relevance and impact of research activities. We further extend this discussion by examining a set of experiential and cognitive factors that are likely to affect the extent to which scientists exhibit a prosocial research behaviour. We believe that our findings provide some new light into the micro-foundations of academic engagement in knowledge and technology transfer activities.

Our quantitative analysis highlights the following aspects. On the one hand, the measure of prosocial research behaviour proposed in this study is found to be strongly associated with many different types of interactions with businesses and technology transfer activities. Therefore, scientists who exhibit a strong awareness about the social impact of research by frequently engaging in tasks associated with the identification of potential results from research or the identification of the potential beneficiaries of research, are more likely to be involved in every form of knowledge and technology transfer: contract R&D, joint research activities with business or firm creation (among others). Our findings also indicate that, while extremely high levels of prosocial research behaviour are rare, a large proportion of scientists exhibit intermediate levels of this type of prosocial behaviour. This highlights that awareness about the social relevance and impact of research is largely to be an inherent part of research endeavours for most scientists.

On the other hand, this paper sheds light on the antecedents of prosocial research behaviour by investigating the type of skills that shape prosocial research behaviour. First, our findings suggest that experience in knowledge and technology transfer activities is a strong precursor of prosocial research behaviour. This type of experience is likely positively affect a sense of perceived feasibility towards technology transfer activities and it is also likely to contribute to a better understanding of the needs and demands of potential beneficiaries of their research. Second, our empirical analysis indicates that cognitive diversity is an important driver of prosocial research behaviour. In this sense, this study highlights that interdisciplinary research tracks could be a powerful means to enhance the formation of favourable attitudes and conducts to engage in knowledge transfer activities. Indeed, the importance of interdisciplinary research is amplified by its moderating role on knowledge transfer experience, as cognitive diversity has a particularly strong impact in shaping prosocial research behaviour among those scientists with no previous experience in knowledge transfer activities. Finally, our results indicate that prosocial research behaviour may conflict with the search for peer recognition through scientific impact, as indicated by the negative sign of the relationship between the prosocial and research excellence, for a significant portion of our sample of scientists. In other words, this finding suggest that, unless researchers perform above average in terms of the scientific impact of their work or conform to the category of star-scientist (in terms of a comparatively high scientific impact of their research), the search for scientific impact may conflict with the development of a prosocial research behaviour. This suggests that policies supporting a change in the set of incentives faced by scientists, such as the inclusion of knowledge transfer activities in the set of merits for academic promotion, could contribute to attenuating the obstacles towards prosocial behaviour faced by a large proportion of scientists.

We believe these contributions are important for two reasons. First, the paper advances theory by putting forward the concept of pro-social research as a behavioural antecedent of knowledge and technology transfer. Second, the paper contributes to the micro-foundations of scientists' engagement in knowledge transfer, by building a comprehensive picture of the type of skills through which pro-social research behaviour is formed and nurtured.

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APPENDIX

Table A1

Details of measures

Variable	Description
Prosocial Research Behaviour	Please, indicate the frequency you engage in each of the following activities when you conduct a research project (1=never; 4=regularly): 1.Identify the potential results of your research that can benefit users 2.Identify the potential users who can apply the results of your research 3.Identify intermediaries in order to transfer the results of your results
Knowledge Transfer Experience	Total value (in €s) of R&D contracts, consulting activities and income from licences of intellectual property rights (i.e. patents) in which the scientists were engaged over the period 1999-2010, as reported in the administrative data provided by CSIC. This variable was transformed logarithmically for the empirical analysis (x_new = ln(x_original +1)).
Research Excellence	Average number of citations per paper and year. For each single paper we computed a score for the average received citations per year (from year of publication until 2010), and then we proceed to sum the scores for all the papers corresponding to each scientist and divided this aggregated figure by the total number of publications of the scientist. This variable was transformed logarithmically for the empirical analysis (x_new = ln(x_original +1)).
Cognitive Diversity	To build this measure, we use the Shannon entropy index, The actual expression of this index is as follows: $\sum_{i=1}^{N} p_i \ln(1/p_i)$, where p_i is the proportion of articles corresponding to the *i*th subject category, and N is the total number of subject categories of the journal articles published by a scientist.
Age	The scientist age, as we know the year in which each scientist was born.
Gender: *Male* =1	A dichotomous variable that takes the value 1 if the scientist gender is Male, and zero if female.
Professor	A dichotomous variable that takes the value 1 if the scientist academic status corresponds to the category of Professor.
Advancing Research	Please, indicate the degree of importance you attach to each of the following items, as personal motivations to establish interactions with non-academic

	organisations (firms, public administration agencies, non-profit organisations) (1=not at all; 4=extremely important): 1. To explore new lines of research 2. To obtain information or materials necessary for the development of your current lines of research 3. To have access to equipments and infrastructure necessary for your lines of research (Cronbach α = 0.72) We computed the average response to these three items.
Expanding Network	Please, indicate the degree of importance you attach to each of the following items, as personal motivations to establish interactions with non-academic organisations (firms, public administration agencies, non-profit organisations) (1=not at all; 4=extremely important): 1. To keep abreast of about the areas of interest of these non-academic organisations 2. To be part of a professional network or expand your professional network 3. To test the feasibility and practical application of your research 4. To have access to the experience of non-academic professionals (Cronbach α = 0.68) We computed the average response to these four items.
Personal Income	Please, indicate the degree of importance you attach to 'Increase your personal income' as a personal motivation to establish interactions with non-academic organisations (firms, public administration agencies, non-profit organisations) (1=not at all; 4=extremely important).
Autonomous Motivation	When you think of your job as a researcher, what is the importance attached to the following items? (1=no importance; 4=extremely important): 1. To face intellectual challenges 2. To have greater independence in your research activities 3. To contribute to the advance of knowledge in your scientific field (Cronbach α = 0.65). We computed the average response to these three items.
Controlled Motivation	When you think of your job as a researcher, what is the importance attached to the following items? (1=no importance; 4=extremely important): 1. Salary 2. Job security. 3. Career advancement. (Cronbach α = 0.71). We computed the average response to these three items.

Number of Publications	Total number of publications over the scientist career until 2010 (included). This variable was transformed logarithmically for the empirical analysis (x_new = ln(x_original +1)).
Average Number of Co-authors	Average number of co-authors per article, for each scientist. This variable was transformed logarithmically for the empirical analysis (x_new = ln(x_original +1)).
Climate	Number of items assessed by the respondent as ‘very positively’, from the following question: Assess the experience you have had in your relationships with the personnel at your institute, regarding the following issues (1=very negatively; 4=very positively): 1. Attitudes of the personnel at your institute to address your queries and requests 2. Accessibility to the human resources and services available at your institute 3. Capacity to solve the problems in due time and form 4. Technical capacity of the institute’s personnel We have computed the count of items assessed as ‘very important’.
Discipline dummies	Dichotomous variables for each of the 8 scientific disciplines. We have considered Biology and Biomedicine as the reference category.

Table A2.

Correlation Matrix

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1. Prosocial Res. Behaviour	1														
2. K. T. Experience (ln)	0.258*	1													
3. Research Excellence (ln)	-0.154*	-0.052	1												
4. Cognitive Diversity	0.043	0.162*	0.239*	1											
5. Advancing Research	0.252*	0.032	0.013	0.022	1										
6. Expanding Network	0.298*	0.041	-0.051	-0.024	0.583*	1									
7. Personal Income	0.073*	-0.023	-0.023	-0.073*	0.261*	0.226*	1								
8. Controlled Motivation	0.085*	0.034	0.005	-0.051	0.103*	0.125*	0.377*	1							
9. Autonomous Motivation	-0.012	0.001	0.082*	-0.079*	0.162*	0.139*	0.073*	0.249*	1						
10. Age	0.083*	0.236*	-0.104*	0.064*	-0.021	-0.056*	0.005	-0.029	-0.096*	1					
11. Gender (Male = 1)	-0.018	0.071*	0.066*	0.053	-0.181*	-0.194*	0.017	0.037	0.039	0.099*	1				
12. Professor	0.038	0.235*	0.116*	0.077*	-0.029	-0.028	0.003	0.060*	0.090*	0.436*	0.162*	1			
13. Number Publications (ln)	-0.019	0.167*	0.392*	0.597*	-0.012	-0.064*	-0.078*	-0.035	-0.031	0.105*	0.065*	0.287*	1		
14. Average N^{o} Co-authors (ln)	-0.012	-0.052	0.338*	0.186*	0.080*	-0.017	-0.061*	-0.012	-0.078*	-0.080*	0.016	-0.031	0.221*	1	
15. Climate	0.125*	0.136*	-0.031	0.041	0.127*	0.157*	-0.023	0.028	-0.008	0.006	0.024	-0.006	-0.004	0.04	1

* $p < 0.05$