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Conducting Pro-Social Research: Cognitive Diversity, Research Excellence And Awareness About The Social Impact Of Research

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Abstract: We propose the concept of pro-social research as reflecting the adoption of 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. Our study investigates 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).

Keywords: Knowledge transfer, cognitive diversity, research excellence, pro-social behaviour
JEL Codes: O31, O32

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1 Introduction

A large 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 (Bercovitz and Feldman 2006, Feller 1990, Spencer 2001). The adoption of knowledge transfer practices has been intensely supported by policymakers (Mowery 2004) through the creation of an institutional environment which encourages the scientific participation in knowledge transfer activities. The growing emphasis to encourage knowledge exchange between the scientific sphere and the societal sphere has been accompanied by an increasing academic attention to the micro-foundations of scientists' engagement in such activities (Rothaermel et al. 2007). This interest partly stems from the complex 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 et al. 2009, Philpott et al. 2011, Sauermann and Stephan 2012, Tartari and Breschi 2012). Researchers adopting an individual-based approach on academic entrepreneurship have pointed out the key role of individual differences in explaining academic entrepreneurship (Fini et al. 2012, Goethner et al. 2012). For instance, Clarysse et al. (2011) highlight the scientists' entrepreneurial orientation and the previous entrepreneurial experience as strong determinants of academic entrepreneurship.

Firm creation is, however, a very specific and rather exceptional channel of knowledge and technology transfer associated to university-business interactions. Indeed, a broader range of formal and informal channels are available for scientists to mobilize scientific knowledge outside the academic environment, such as by patenting their research results or by engaging in consulting activities with non-academic organizations (Murray 2004, Salter and Martin 2001). Comparatively less is known about the extent to which

cognitive and motivational factors shape the adoption of a research mode that embraces high sensitivity to the societal impact of research (Audretsch and Erdem 2004) and facilitates a subsequent involvement of scientists in a broad range of knowledge transfer endeavours with non-academic actors. We contend that focusing on the individual determinants underlying the adoption of this research mode offers an opportunity to understand why the engagement of scientists in knowledge transfer activities is highly concentrated in few individuals (Agrawal and Henderson 2002, Haeussler and Colyvas 2011).

In an effort to shed light on the antecedents of the scientists' engagement in various forms of knowledge transfer activities, we propose the concept of pro-social research behaviour. An analysis of scientists' pro-social research behaviour allows us to examine why some scientists are more successful than others in reconciling the complicated tensions inherent in adopting a mindset compatible with knowledge transfer with non-academic actors. Drawing on organizational behaviour literature (e.g.:_Brief and Motowidlo 1986, Grant and Sumanth 2009, Grant 2007, Penner. et al. 2005), we introduce the concept of pro-social research behaviour as the adoption of 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 a broad range of knowledge transfer activities. We also investigate the impact that different cognitive aspects have on the development of pro-social research behaviour, once controlling for motivational aspects. In particular, we examine if certain individual-level attributes (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.

This article makes a number of contributions to the literature. First, it proposes the concept of pro-social research behaviour as an antecedent of the scientists' subsequent participation in various forms of knowledge transfer activities. A focus on the individual antecedents of knowledge transfer is especially critical in the context of academic scientists, where scientists normally enjoy high levels of autonomy to decide to what extent they interact with non-academic actors (Tartari and Breschi 2012). In this regard, few studies have examined the potential individual-level antecedents of the adoption of a research mode that facilitates the engagement in knowledge transfer activities. Second, this article proposes and tests three individual differences between scientists that may partly explain why some scientists systematically show higher participation in a range of knowledge transfer activities with non-academic actors. Because we are able to control for a number of potential individual-level determinants that may affect the scientists' propensity to embrace a pro-social research behaviour, our study proposes the existence of behavioural antecedent directly related to the scientists' subsequent participation 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 pro-social 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.

2 Background and Hypotheses

2.1 Science and Societal Impact of Research

Traditionally, scientists' behaviour has been explained under an "academic logic" based on the classical (Merton 1973) model of science (Sauermann and Stephan 2012). Norms and incentive structures governing this logic give primacy to the quest for fundamental understanding and the creation of scientific knowledge as the main driver of scientific research. Under this paradigm, scientists' rewards mainly come in the form of peer recognition and higher academic reputation inside their scientific community. The system of science, however, has suffered a variety of changes in the last decades. New models of knowledge production such as the "Mode 2" research (Gibbons et al. 1994), the "academic capitalism" (Slaughter and Leslie 1997), the "entrepreneurial science" (Etzkowitz 1998) or the "post-academic science" (Ziman 2002) have opened up the discussion about the different ways in which science is organized and performed. A common feature of these new possible configurations of knowledge production is an increased effort to interact with other societal spheres such as governments and industry. According to (Hessels and Van Lente 2008), "Mode 2 knowledge is rather a dialogic process, and has the capacity to incorporate multiple views. This relates to researchers becoming more aware of the societal consequences of their work (social accountability). Sensitivity to the impact of the research is built from the start" (p. 742). Researchers are being pushed by public funding agencies in the direction of delivering a clear social utility of the knowledge they produce (Bornmann 2013). That implies that agents from the academic side are expected to being much more conscious about the particular needs and interests of other societal actors and infuse a clearer social orientation to their work. The quest for a societal impact of scientific research is also well reflected in what (Stokes 1997) has called the "Pasteur's Quadrant". This typology of research modes suggests that, even if scientists direct their efforts to the generation of fundamental knowledge, there is wide room for different degrees of inspiration by the potential considerations of use of research results. In other words, having in mind the potential impact of scientific research to non-academic agents is explicitly recognized as an individual-level

preference which is irrespective of the basic or applied nature of the research performed by the scientist (Stokes, 1997).

The decision by individual scientists to actively embrace a range of knowledge transfer activities may be viewed as a signal of their acceptance or not of the macro-level pressures derived from the new models of knowledge production. Indeed, making the switch from a scientific system governed by the traditional norms of science to the adoption of new socio-economic rules of knowledge production poses a great challenge for scientists. In this respect, research shows that there is significant variation in the scientists' responses to the shifting norms of the scientific knowledge production system (Owen-Smith and Powell 2001) and hence, the participation in knowledge transfer activities is highly concentrated in some researchers (Bercovitz and Feldman 2008, Haeussler and Colyvas 2011). These results seem to suggest the existence of individual-level determinants associated with a subsequent participation in knowledge transfer activities. The next section builds on the pro-social behaviour literature to explore potential individual mechanisms and processes that may account for the differences among scientists' engagement in various forms of knowledge transfer.

2.2 Pro-social Organizational Behaviours

Research on pro-social behaviour has received considerable attention among organizational behaviour scholars (e.g.: De Dreu & Nauta, 2009; Grant & Sumanth, 2009; Grant, 2007; McNeely & Meglino, 1994). (Brief and Motowidlo 1986) conceptualized pro-social 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 pro-social 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 pro-social behaviours and in their pro-social values (Audrey et al. 1997, Meglino and Korsgaard 2004). Pro-social 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 et al. 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 pro-social behaviours helps individuals to experience their work as more meaningful, enhancing their feeling of social worth in the workplace (Perry and Hondeghem 2008).

Given its importance for the organizational functioning, a substantial amount of research has gone into explaining the determinants of pro-social behaviour. Pro-social 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 and MacCoun 1985). Recent research revealed that, while carrying out their work, individuals define their identities in terms of helping within specific roles (Penner. et al. 2005). Hence, it has been argued that the particularities of the work itself are likely to exert a considerable effect in the emergence of pro-social identities and pro-social behaviours among individuals. Nevertheless, understanding the particular combination of individual attributes and working features more prone to activate pro-social behaviours still remains an open issue for further research.

The emergence and maintenance of pro-social behaviours is particularly interesting in the context of mission-driven organizations (Brickson 2007). Mission-driven 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. However, evidence reveals that not all individuals working in mission-driven organizations have clear information about the positive effect they may exert on others through their work (Grant & Sumanth, 2009). For instance, it can take years for biomedical researchers to see a positive impact of their work on

patients. In the section below, we move to the determinants of the emergence of pro-social behaviours among scientists within the context of a public research organization.

2.3 Pro-social Research Behaviour as a Precursor to Engagement in Knowledge Transfer

From a policymakers' standpoint, the engagement of research scientists in knowledge transfer activities seems to be highly desirable. Evidence suggests, however, that creating policy initiatives does not automatically result in higher levels of scientists' participation in knowledge transfer activities. Scientists rather differ in their adaptation to the new rules of the game because they are motivated by a range of personal and institutional incentives that differ between scientists (Bercovitz and 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 (Owen-Smith and Powell 2001, Philpott et al. 2011, Tartari and Breschi 2012) and entails a modification of the scientists' role identity (Jain et al. 2009) towards one that is compatible with the engagement in knowledge transfer activities. This raises the possibility that psychological processes related to the perceived usefulness of the scientists' research activities may foster or detract scientists to participate in knowledge transfer activities. In this sense, the feelings of task significance and social worth associated to the undertaking of pro-social behaviours (Grant et al., 2007) may be helpful to explain why certain scientists are more successful than others in accepting this new mode of scientific knowledge production.

Taking research scientists as our unit of analysis, we propose to analyze the scientists' adoption of a research mode that considers the social relevance of the research results through a pro-social behaviour lens. Employing the concept of pro-social research behaviour allows us to provide a socio-psychological basis to study the individual-level determinants and consequences of explicitly adopt a pro-social research behaviour mode. Specifically, we define pro-social research behaviours as those conducts that place societal relevance as a primary goal of research. We argue that this societal relevance may be reflected in three different but highly related research

conducts that might be performed by scientists. First, an explicit recognition that one's research results might have a *potential social impact* in other people or groups (Shane and Venkataraman 2000). Second, an explicit identification of the *potential users* of research findings (Gibbons et al. 1994, Stokes 1997). Third, an explicit identification of those *intermediate agents* that may serve to channel the social impact of research (Jain et al., 2009).

A key feature that is shared between the three conducts is an explicit interest in exerting an impact that goes beyond the academic context. An interest in benefiting others through the research findings and an explicit recognition of the channels through which this social impact may be materialized clearly indicates an adoption of a research mode substantially divergent from the Mertonian model of science. Interestingly, organizational psychology scholars point out that 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 (Grant and Sumanth 2009, Thompson and Bunderson 2003) and be less emotionally exhausted (Grant & Sonnentag, 2010). Further, individuals with other-focused outcome goals tend to be more committed and dedicated towards these goals (Thompson & Bunderson, 2003). In this regard, engaging in conducts that place social relevance at the forefront of the scientists' research activities may anticipate that this interest might be materialized through the engagement in knowledge transfer activities, even if the participation in these practices go beyond the traditional role of scientists.

The role of pro-social identities and pro-social motivation has been recently incorporated into the academic entrepreneurship and knowledge transfer literatures. Recently, Lam (2011) studied the scientists' determinants to engage in research commercialization activities and found that the scientists' personal interest to exert a positive impact on others was acknowledged as one of the underlying reasons for the adoption of commercial practices in the scientists' research behaviour. Likewise, Weijden et al. (2012) interviewed 188 research leaders of biomedical research groups and found that their attitude towards the societal impact of their research activities partially

explained their subsequent generation of non-academic outputs addressed to various non-academic agents such as the general public or patient organizations. These studies call attention to the adoption of 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. However, existing research do not elucidate which are the specific conducts that place social relevance at the forefront of the scientist' research activities and do not explore the role of individual-level characteristics underlying the adoption of such conducts. In the section that follows we examine a set of potential individual-level factors that may explain the scientists' adoption of a pro-social research behaviour.

2.4 Antecedents of Pro-social Research Behaviours

We extend the knowledge transfer literature by examining the factors that contribute to the configuration of pro-social research behaviour among scientists, as characterised above. More specifically, we are interested in identifying those individual-level features that are conducive to pro-social 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 determinants to predict the emergence of pro-social research behaviour: research excellence and cognitive diversity.

2.4.1 Knowledge transfer experience

First, we can reasonably expect that knowledge transfer experience matters in shaping pro-social 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 and Pries 2009, Krueger et al. 2000, Landry et al. 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 a pro-social attitude (Goldman & Fordyce, 1983. Grant et al., 2007; Grant, 2007), we propose that having previous knowledge transfer experience can increase scientists' pro-social 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 and 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 and Humphrey 2006) and increase work persistence and job performance.

Building on this logic, we expect that having previous ties with the beneficiaries of one' work should be particularly relevant among scientists to facilitate and inspire pro-social research behaviours. In an institutional work environment with high pressure to perform according to academic metrics (Bercovitz and 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. Another important consequence of past experience is related to the development of useful knowledge and skills. Research from academic entrepreneurship literature highlight that previous experience provides the opportunity to acquire task-relevant knowledge and skills (Dokko et al. 2009, Owen-Smith and Powell 2003) which enhance the scientists' ability towards this task. Other scholars invoke to the concept of self-efficacy to argue that scientists who have been previously involved in knowledge transfer with non-academic actors are likely to increase their own belief in their ability to successfully deal with non-academic actors (Clarysse et al. 2011)

and hence, the chances to consider their particular needs in their research activity. Accordingly, we put forward the following hypothesis:

Hypothesis 1: *Prior experience in knowledge transfer is positively associated with pro-social research behaviour.*

2.4.2 Research Excellence

A number of studies indicate that research excellence is likely to substantially affect the scientists' tendency to actively engage in knowledge transfer activities (Calderini et al. 2007, Link et al. 2007, Perkmann et al. 2011). The quantity and quality of academic publications is a recognized indicator of research excellence and 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 and Rothaermel 2012). As a consequence, high scientific performers are more able to send credible signals to external actors (Spence 1973). A scientist with high scientific visibility may anticipate a potential to exert powerful signals to non-academic beneficiaries and therefore, will be more likely to orient their research towards them and develop awareness about the potential beneficiaries of their research. 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 and Motowidlo 1986, Mowday 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 on others (Penner. et al. 2005).

While research excellence is likely to predict pro-social 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 pro-social 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:

Hypothesis 2a: *Research excellence is positively associated with pro-social research behaviour.*

Hypothesis 2b: *There is a curvilinear J-shape relationship between research excellence and pro-social research behaviour such that researchers exhibit lower pro-social research behaviour at low and intermediate levels of research excellence.*

2.4.3 Cognitive diversity

Third, we hypothesise that cognitive diversity is positively linked to conducting pro-social research. Cognitive diversity refers to the knowledge breadth of a research scientist, measured as the diversity and balance of the areas of research in which the scientist works (Rafols and Meyer 2010).

Entrepreneurship research (Fitzsimmons and Douglas 2011, Philpott et al. 2011) 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 the identification of new lines of inquiry and the awareness of social relevance and commercial opportunities of their research (D'Este et al. 2012, Fleming et al. 2007) . 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 pro-social 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). Further, addressing and solving societal problems is best achieved when scientists are equipped with a higher cognitive breadth (Stirling 1998). In this sense, past research has shown that scientists with greater experience outside academia reported higher levels of scientific knowledge breadth (van Rijnsoever and Hessels 2011). Management research on diversity also emphasizes the multiple consequences of counting with a broad pool of knowledge. For instance, Milliken and Martins (1996) suggests that higher levels of diversity in a group facilitate the creation of linkages to those outside the group, allowing them to account for the particular needs of different social groups. At the scientist level, we expect that those scientists having higher cognitive diversity will be more able to consider the potential needs of non-academic actors in their research activities.

However, being equipped with a wide breadth of knowledge also has certain drawbacks. Scientists with high levels of cognitive diversity face increasing challenges for knowledge integration and coordination when broader and distant bodies of knowledge are dealt with (Cummings and Kiesler 2005, Rafols 2007). Coordination costs result from the difficulties of integrating different bodies of knowledge, and comprise aspects such as the scientists' need to overcome the lack of a common scientific language across the different fields, as well as the problems associated with coordinating the heterogeneous meanings and norms governing each scientific field. We argue that, after a certain threshold, the coordination costs derived from high cognitive diversity may be detrimental with regards to their awareness about the social relevance of the scientific knowledge that they produce. Hence, we predict that this relationship may

exhibit an inverted U-shape. Drawing on this discussion, we put forward the following two related hypotheses:

Hypothesis 3a: *Cognitive diversity is positively associated with pro-social research behaviour.*

Hypothesis 3b: *This relationship may exhibit an inverted U-shape if increasing levels of cognitive diversity have a decreasing effect on scientists' pro-social research behaviour.*

2.4.4 Substitution effects

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 pro-social research behaviour among scientists with no (or little) knowledge transfer experience, compared to those scientists who have a high knowledge transfer experience and therefore have already developed the required enacting skills for engaging in pro-social research behaviour. We expect that high scientific visibility and self-confidence about one's research abilities would compensate for the absence of knowledge transfer experience, contributing to eliciting a pro-social attitude and conduct particularly among those with little or no prior knowledge transfer experience. To put it differently, the positive effect of previous knowledge transfer experience on the scientists' pro-social research behaviour will be higher in scientists with less research excellence. Scientists with less academic reputation have more difficulties in exerting signals to non-academic agents. This means that the ability, skills and self-efficacy acquired in previous knowledge transfer activities with external agents will be particularly relevant in prompting them to engage in pro-social research behaviour when they lack the academic visibility given by an outstanding research track.

Similarly, we expect that cognitive diversity would have a particularly stronger role in the formation of a pro-social 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. As mentioned above, cognitive diversity is related to a greater capacity to integrate distant bodies of knowledge. We expect that the set of skills related

to high cognitive diversity may compensate for the lack of ability and specific skills among those scientists with less previous experience in knowledge transfer. We therefore put forward the following two related hypotheses:

Hypothesis 4*: Research excellence has a higher impact on pro-social research behaviour at lower levels of experience in knowledge transfer activities.*

Hypothesis 5*: Cognitive diversity has a higher impact on pro-social 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 around here]

3 Method

3.1 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[4]. However, as shown in Table 1, while response rates are overall similar by fields of science, there are some

[4] 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.

disciplines that are overrepresented (such as: Agriculture, Chemistry and Food Science & Technology) while Social Sciences and Humanities is significantly underrepresented.

[TABLE 1 around here]

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. Since we combined three different data sources, the potential problem of common method bias (CMV) is largely controlled (Podsakoff et al., 2003). Another potential concern with our data is that respondents may have a tendency to provide socially desirable answers to our "pro-social research behaviour" question. To minimize the possibility of social desirability bias (SDB) (Moorman and Podsakoff 1992), respondents were promised full anonymity in their responses. Moreover, our respondents hold permanent positions and their evaluation is not directly linked to the generation of "socially useful" knowledge. Therefore, it seems unlikely that respondents inflate their responses in the questionnaire.

3.2 Measures

Our dependent variable, ***Pro-social 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 from '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 pro-social 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.[5] This indicates that, overall, scientists engage at intermediate or moderate levels in the three activities we have considered to measure pro-social behaviour, with almost no differences across fields of science.[6] 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).[7]

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) with zero citations to their work. Similar to the previous variable (*knowledge transfer experience*), we also transformed this variable logarithmically.

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[5] The distribution departs however from normality due to significant levels of Kurtosis.

[6] There are largely no significant differences in pro-social 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.

[7] 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.

Our measure of ***cognitive diversity*** is based on the number of ISI subject categories (SC) 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. Therefore, a higher Shannon score reflects that the scientist is familiarized with a wide range of different bodies of knowledge. 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.[8] 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 corresponds to a scientist who, despite having the same

[8] 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.

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 pro-social research behaviour, we also considered some alternative individual-level control variables. First, we included socio-demographic characteristics of our sample of scientists, such as the age of researchers (*Age*), the gender (whether the researcher is *Male*), and the academic status (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 pro-social 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 N^{o} 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 2).

[TABLE 2 around here]

4 Results

4.1 Pro-social Research Behaviour and Engagement in Knowledge Transfer

Drawing upon our conceptual framework, the adoption of pro-social 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 pro-social 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 pro-social research behaviour and their degree of involvement in knowledge transfer activities.

To that effect, we examined the relationship between conducting pro-social research and engaging in knowledge transfer activities, using the information gathered through the survey questionnaire. We distinguished scientists who scored high in pro-social research behaviour, defined as those with pro-social levels within the highest third-tile (i.e. those 33% of scientists who score highest in pro-social research behaviour), and compared them to scientists whose pro-social 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 pro-social 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 pro-social research behaviour engage in 'R&D Contracts' with businesses, compared to a proportion of 20% for researchers scoring low in pro-social 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 pro-social research and engagement in knowledge transfer activities.

[FIGURE 2 around here]

4.2 Antecedents of Pro-social Research Behaviour

We run Tobit regression analysis given that our dependent variable, *Pro-social research behaviour*, takes values ranging between 1 and 4. We investigate the direct impact of prior experience in knowledge transfer, research excellence and cognitive diversity on pro-social research behaviour, and the extent to which cognitive-related skills moderate the relationship between knowledge transfer experience and pro-social research behaviour.[9]

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 pro-social 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

[9] 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)

explaining pro-social 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 pro-social research behaviour.

However, when examining whether there is a curvilinear relationship between research excellence and pro-social 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 pro-social 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 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 pro-social 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). To interpret the form of the interaction, the high and low levels of cognitive diversity are plotted in Figure 4. The slopes suggest that previous knowledge transfer experience is more strongly associated with pro-social research behaviour as the scientists' cognitive

diversity decreases. That is, the impact of cognitive diversity on pro-social 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 pro-social 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 around here]

[FIGURE 3 around here]

[FIGURE 4 around here]

5 Discussion

5.1 Contribution and practical implications

This study aims to provide a deeper understanding of the drivers of knowledge and technology transfer engagement among scientists by bringing to the foreground the concept of pro-social research behaviour. Although new modes of scientific knowledge production (Etzkowitz 1998, Gibbons et al. 1994, Ziman 2002) stress the importance to incorporate the needs of societal actors on the process of scientific knowledge creation, little work has actually paid attention to the behavioural antecedents of knowledge transfer and, in particular, to a the existence of a research mode that places social relevance as a primary goal or research. An important contribution from this study is the contention that this research mode is comprised by three conducts: (i) an explicit recognition that one's research results might have a *potential social impact* in other people or groups, (ii) an explicit identification of the *potential users* of research findings and (iii) an explicit identification of those *intermediate agents* that may serve to channel the social impact of research. A fundamental argument in this research is that the scientists' adoption of these conducts may act as a bridge to connect the academic logic and the business logic and, to some

extent, to predict the subsequent engagement of scientists in a range of knowledge transfer activities. Thus, the present study aims to contribute to recent calls for research on the micro-foundations of the scientists' engagement in knowledge transfer activities (Jain et al 2009; Shane 2004).

Our study found preliminary evidence of a close relationship between the scientists' pro-social research behaviour and the subsequent participation in knowledge transfer activities. Specifically, we found that 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 contract R&D, joint research activities with business or firm creation (among others). Our findings also indicate that, while extremely high levels of pro-social research behaviour are rare, a large proportion of scientists exhibit intermediate levels of this type of pro-social behaviour.

The fact that the participation in knowledge transfer activities is skewed in few individuals is particularly noteworthy for the purpose of this research because it indicates a high degree of heterogeneity at the individual level. By bringing into the discussion research on pro-social behaviours from the social psychology literature (e.g.: De Dreu and Nauta 2009, Grant and Berry 2011, Grant 2008), our study aims to provide insights on the individual level sources of such heterogeneity. Explicitly, we examine the role of three types of individual antecedents of scientists: previous knowledge transfer experience, research excellence and cognitive diversity. First, our findings suggest that experience in knowledge and technology transfer activities is a strong precursor of pro-social research behaviour. This type of experience is likely to positively affect a sense of perceived feasibility towards knowledge 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 pro-social 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 a pro-social research behaviour among those scientists with no previous experience in knowledge transfer activities. Finally, our results indicate that pro-social research behaviour may conflict with the search for peer recognition through scientific impact, as indicated by the negative sign of the relationship between pro-social research behaviour 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 pro-social research behaviour.

Facilitating the scientists' engagement in knowledge transfer activities has become an increasingly important issue from a policy perspective. Our study offers implications for scientists, research managers and policymakers. Although there are good reasons for policymakers to focus their efforts on the creation of an institutional environment that facilitates knowledge transfer, this study suggests that a closer look at the individual level is also needed. Given that the academic and the commercial incentives are misaligned, some scientists prioritize their academic career over the social impact of the knowledge they produce. Our results suggest that policies supporting knowledge transfer may be more effective if they are accompanied by an explicit change in the rewarding system of scientists. For instance, the inclusion of knowledge transfer activities in the set of merits for academic promotion could contribute to attenuating the obstacles towards pro-social research behaviour faced by a large proportion of scientists. Our findings points out the crucial role played by cognitive diversity as substitutes for previous knowledge transfer experience. Results from this study encourage scientists with less prior knowledge transfer experience to diversify their knowledge breath by collaborating with scientists from different research communities, as the type of skills derived from high cognitive diversity may compensate for the absence of prior knowledge transfer experience in the adoption of a pro-social research behaviour. Furthermore, research managers may want to devote attention

to encourage scientists to perform interdisciplinary research as a way to promote pro-social research behaviour. In this sense, the support of interdisciplinary research tracks and interdisciplinary research training could be a powerful means to enhance the formation of favourable attitudes and conducts to engage in knowledge transfer activities.

5.2 Limitations and future directions

Our study is subject to a number of limitations that point to fruitful directions for further research. First, our empirical study is focused in one single research organization –scientists from the Spanish Council of Scientific Research (CSIC). While this allows us to control for potential factors at the organizational level that may have an influence on the scientists' pro-social behaviour, examining one single organization may limit the generalizability of the results presented here. Although we included scientists from a range of scientific disciplines and academic positions, it is nevertheless possible that the results are not generalizable to other organizations. Compared to university researchers, CSIC scientists are mainly dedicated to perform scientific research. This implies that the adoption of a pro-social research behaviour among university researchers may be driven by a different set of determinants. Future research sampling scientists from a wider range of organizations may be useful in addressing this issue.

Despite of the fact that our analysis controls for the scientific field of scientists, we cannot rule out that the adoption of a pro-social research behaviour may be field-specific. Future analyses should expand the target population in order to examine the determinants of pro-social research behaviour for each scientific field separately. That would allow identifying whether there are differences across scientific fields in the adoption of a pro-social research behaviour.

Further, we are aware that the adoption of a pro-social research behaviour from an individual-level approach is difficult to predict by nature, given that there are a large number of potential factors at the individual level that may also account for the formation of a favourable attitude towards knowledge transfer. While our research controls for a range of motivational variables, future studies are needed to unpack the role of other variables at the individual level that may

influence the individuals' propensity to exchange knowledge. In particular, analysing how different personality traits nurture the adoption of a pro-social research mode may be a fruitful avenue for further research.

Tables and Figures

Tab. 1 Response rates by field of science (n = 1295)

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.

Tab. 2 Descriptive statistics

Variables	Mean	S.D.	Median	Min.	Max.	Obs.
1. Pro-social Research Behaviour	2.516	0.731	2.333	1.000	4.000	1219
2. Knowledge transfer 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. Motive 1: Advancing research	1.108	0.522	1.000	0.000	2.000	1237
6. Motive 2: Expanding network	0.859	0.509	1.000	0.000	2.000	1235
7. Motive 3: 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.

Tab. 3 Tobit estimates. Dependent variable: pro-social research behaviour

	Pro-social research behaviour					
Variables	(1)	(2)	(3)	(4)	(5)	(6)
Knowledge transfer 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)
Ressearch excellence^2			0.206*			
			(0.110)			
Cognitive diversity^2				0.019		
				(0.036)		
Research Excellence* Knowledge transfer experience					-0.004	
					(0.010)	
Cognitive diversity * Knowledge transfer experience						-0.012**
						(0.006)
Motive 1: Advancing Research	0.214***	0.204***	0.205***	0.203***	0.204***	0.209***
	(0.052)	(0.051)	(0.051)	(0.051)	(0.051)	(0.051)
Motive 2: Expanding Network	0.311***	0.302***	0.302***	0.303***	0.302***	0.295***
	(0.053)	(0.052)	(0.052)	(0.052)	(0.052)	(0.052)
Motive 3: Personal Income	-0.033	-0.018	-0.019	-0.017	-0.018	-0.018
	(0.044)	(0.042)	(0.042)	(0.042)	(0.042)	(0.042)
Controlled motivation	0.058*	0.051	0.052	0.049	0.051	0.051
	(0.034)	(0.033)	(0.033)	(0.033)	(0.033)	(0.033)
Autonomous motivation	-0.078*	-0.064	-0.062	-0.062	-0.064	-0.061
	(0.049)	(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)	0.087**	0.067	0.067	0.068	0.067	0.068
	(0.047)	(0.046)	(0.046)	(0.046)	(0.046)	(0.046)
Professor	0.019	0.001	-0.005	-0.001	0.002	0.004
	(0.060)	(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	0.020	0.046	0.047	0.045	0.046	0.048
	(0.041)	(0.041)	(0.041)	(0.041)	(0.041)	(0.041)
Climate	0.020*	0.008	0.008	0.008	0.008	0.007
	(0.012)	(0.012)	(0.012)	(0.012)	(0.012)	(0.012)
Intercept	1.322***	1.750***	1.654***	1.736***	1.750***	1.738***
	(0.277)	(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.

Fig. 1 Theoretical Model

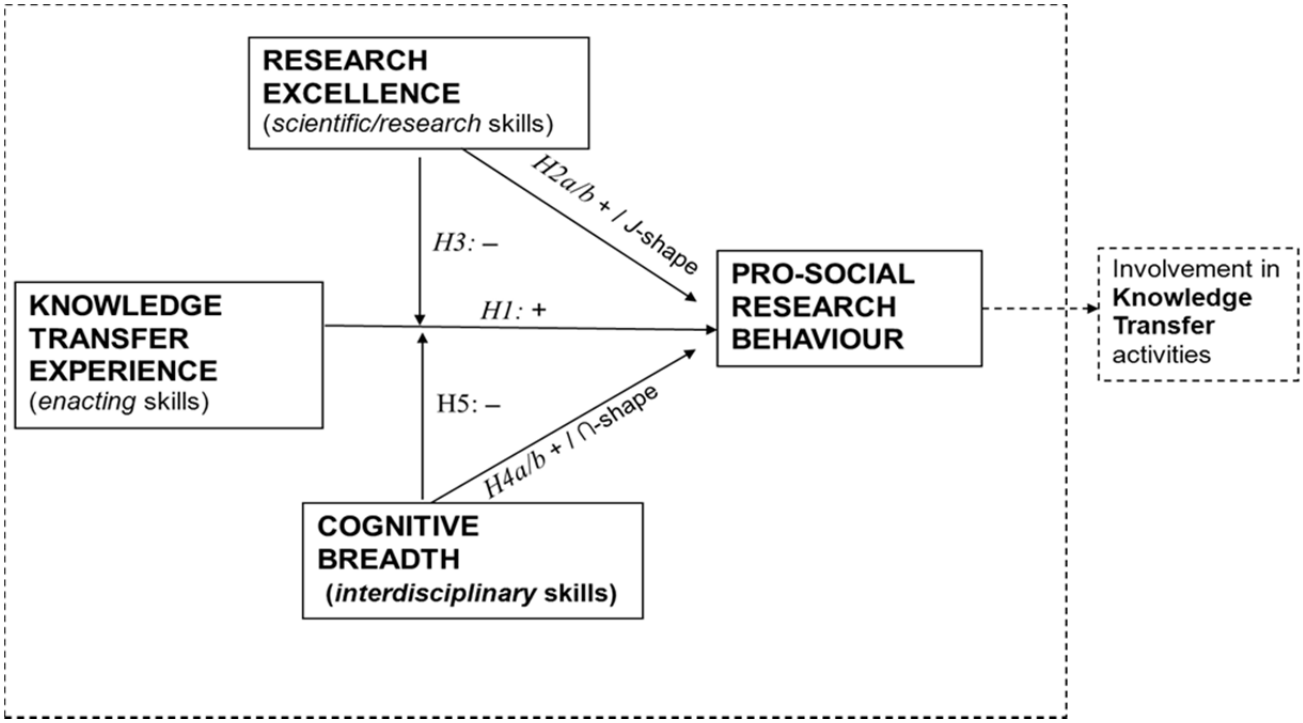


Fig. 2 Pro-social research behaviour and engagement in knowledge transfer

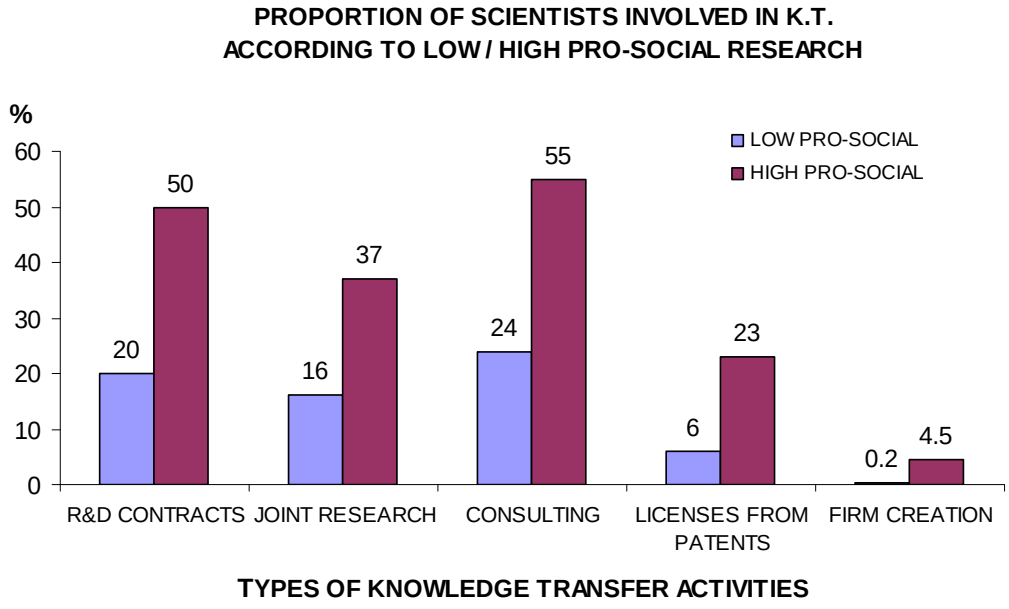


Fig. 3 Relationship between research excellence and pro-social research behaviour

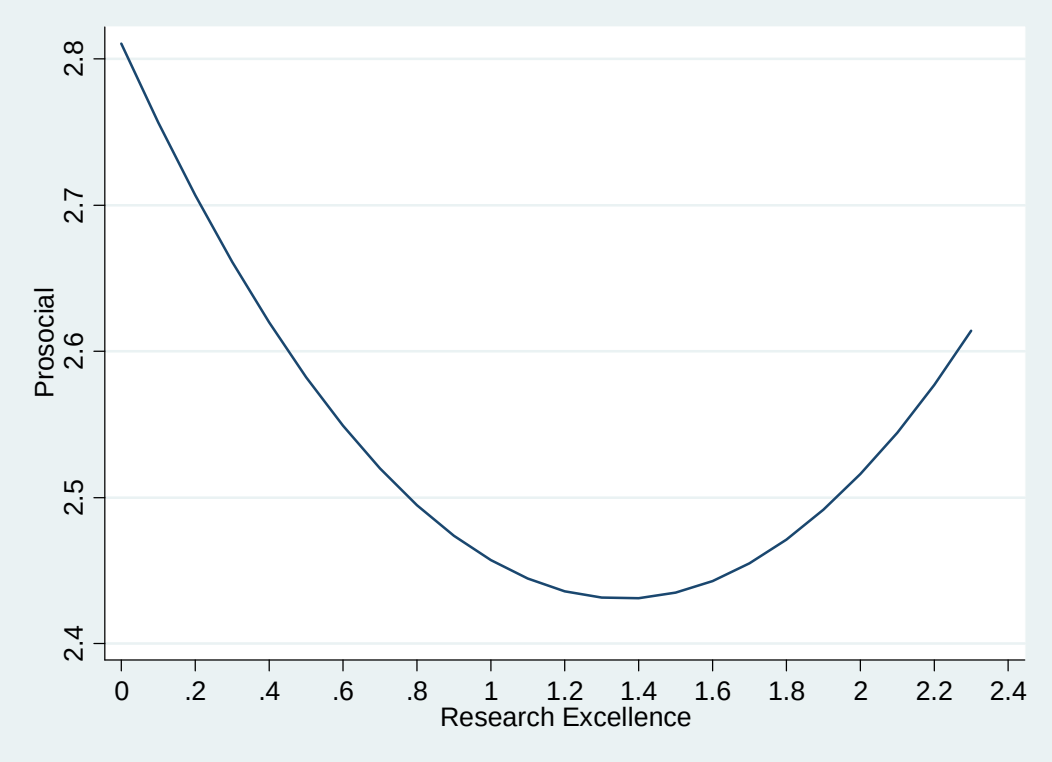
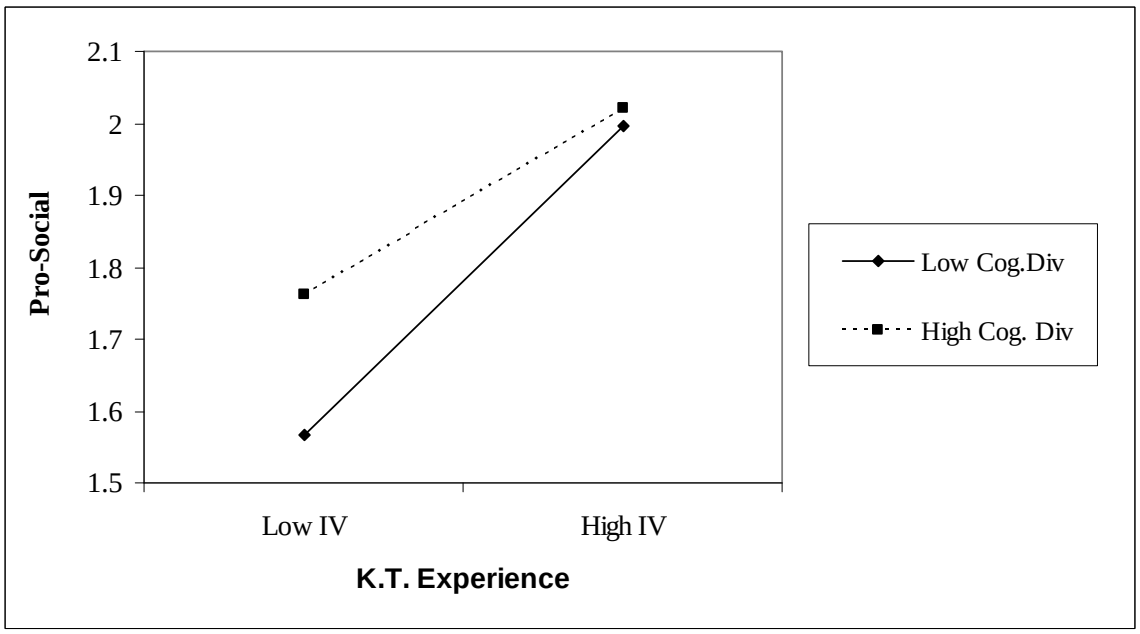


Fig. 4 Regression slopes for the interaction of knowledge transfer experience and cognitive diversity



Appendix

Tab. A1 Details of measures

Variable	Source	Description
Pro-social Research Behaviour	Questionnaire	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	Administrative data	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	ISI-SCI database	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	ISI-SCI database	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	Administrative data	The scientist age, as we know the year in which each scientist was born.
Gender: *Male* =1	Administrative data	A dichotomous variable that takes the value 1 if the scientist gender is Male, and zero if female.
Professor	Administrative data	A dichotomous variable that takes the value 1 if the scientist academic status corresponds to the category of Professor.
Advancing Research	Questionnaire	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 $\alpha = 0.72$) We computed the average response to these three items.
Expanding Network	Questionnaire	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	Questionnaire	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	Questionnaire	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	Questionnaire	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	ISI-SCI database	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	ISI-SCI database	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	Questionnaire	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	Administrative data	Dichotomous variables for each of the 8 scientific disciplines. We have considered Biology and Biomedicine as the reference category.

Tab. A2 Correlation Matrix

	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
1. Pro-social 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

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