The importance of pro-social behaviour for the breadth and depth of knowledge transfer activities: An analysis of Italian academic scientists

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The importance of pro-social behaviour for the breadth and depth of knowledge transfer activities: An analysis of Italian academic scientists

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Abstract

The debate on the entrepreneurial university has raised questions about what motivates academics to engage with the external environment and what forms knowledge transfer (KT) activities should take. This paper distinguishes between the variety of forms of engagement (KT breadth) and the intensity of collaboration (KT depth) in the analysis of their motivations. The paper relies on a sample of Italian academics from different scientific fields over the period 2004–2008. Whereas previous literature has shown that academics are essentially motivated by learning opportunities, fundraising and satisfaction derived from puzzle solving in research activities, our paper provides evidence of the positive role of an additional motivation for both the breadth and depth of KT: the extent to which the academic scientist advances the societal role of universities ("mission" motivation). We find that both "funding" and "mission" motivations have a positive effect on the variety and intensity of KT activities, with little effect for learning opportunities. Our results show also a higher effect of "funding" and "mission" on the depth of KT activities compared to their breadth.

Keywords: motivation; knowledge transfer; third mission; university external engagement

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1. Introduction

A central theme in the industrial and technology policy debate in recent years has revolved around the exploitation of knowledge created at universities to spur the development of old and new sectors and eventually economic growth (e.g., European Commission, 1995, 2007; OECD 2002a, 2002b). Governments at regional, national and international levels consider the "entrepreneurial university" as having an important role to play in the economic development of their region via knowledge transfer (KT) to the industrial sector (Etzkowitz and Leydesdorff, 2000; Etzkowitz, 2003).

Although existing studies have recognised that KT activities can take multiple forms (Perkmann et al., 2013; Landry et al., 2007, 2010; D'Este and Patel, 2007; Siegel et al., 2007), most of the studies to date have focused on specific types of KT activities, mainly patenting, spin-offs and licensing (Azoulay et al., 2009; Thursby and Thursby, 2002, Dechenaux et al., 2011; Shane and Stuart, 2002; Rothermael et al., 2007). Only recently have a number of contributions considered a broader set of KT activities and focused on the motivation of academics to perform these activities (Ramos-Vielba et al., 2016; Olmos-Peñuela et al., 2014; D'Este and Perkmann, 2011; D'Este and Patel, 2007; Link et al. 2007), their complementarities (Landry et al., 2010) and their effects on effective KT (Landry et al., 2007).

This stream of literature has shown that academic engagement is mainly influenced by individual characteristics (Link and Scott, 2012), organisational and institutional factors (Moog et al., 2015; Ding and Choi, 2011; Jensen and Thursby, 2001), the scientific discipline of the academic (Bekkers and Bodas Freitas, 2008) and a combination of intrinsic and extrinsic motivations: fundraising, access to knowledge and learning (D'Este and Perkmann, 2011; Lam, 2011).

We add to this literature by showing the central role played by an additional type of intrinsic motivation: the desire for academic scientists to advance the societal role of universities (following the transformative potential that universities have for current society). Indeed, the "Third mission" of universities has gained momentum in recent years and has been strongly promoted by governments as a means to favour territorial development and growth (Etzkowitz and Leydersdorff, 2000). We provide evidence on how scientists are motivated by this "mission" with respect to the variety of forms of external engagement (KT breadth) and the intensity of collaboration (KT depth).

We rely on an in-depth survey of 133 Italian academics from different scientific fields (Life Sciences, Chemistry, Mathematics and Physics, Engineering and Medical Sciences) over the period 2004–2008. Our results show the existence of a positive and significant role of funding and mission motivations on scientists' engagement with the external environment. This role is relevant for both the variety (KT breadth) and the intensity (KT depth) of scientists' external collaboration, but we find evidence for a higher effect of funding and mission motivations on the depth of KT activities compared to their breadth.

The paper is structured as follows. Section 2 provides a review of the relevant literature and the main research questions, section 3 presents data and methodology, section 4 discusses the results and section 5 concludes.

2. Literature review and research questions

2.1. Variety and intensity of knowledge transfer activities: A tale of breadth and depth

Previous literature has provided extensive evidence on the different forms of KT activities (see the review by Perkmann et al., 2013; also Rothaermel et al., 2007). Most of the attention has been devoted both to university–industry interactions and to a restricted number of channels, primarily commercialisation: patents, licensing and spinoffs (Azoulay et al., 2009; Shane and Stuart, 2002; Thursby and Thursby, 2002). Most universities around the world have created facilities specifically devoted to the commercialisation of academic inventions, such as science parks, technology transfer offices and incubators (Hsu et al., 2015). Governments have also supported this form of university–industry interaction by providing funding for these facilities or grants for collaborative projects (Leydersdorff and Etzkowitz, 1996).

However, more recent contributions have highlighted how the actual scale and impact of scientists' overall external engagement activities might be underestimated as a result of neglecting other forms of KT activities, such as R&D contracts, consulting, staff exchange and joint student supervision (Abreu and Grinevitch, 2013; D'Este and Patel, 2007; Perkmann

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and Walsh, 2007). A number of studies have thus considered a broader set of KT activities, focusing on academics' propensity to undertake them (Ramos-Vielba et al., 2016; Olmos-Peñuela et al., 2014; D'Este and Perkmann, 2011; Landry et al., 2010; Grimpe and Fier, 2010; D'Este and Patel, 2007; Link et al. 2007) and their relative effects (Landry et al., 2007; D'Este et al., 2013; Sánchez-Barrioluengo, 2014). For example, D'Este and Patel (2007) are among the first to include contract research and consulting activity in the analysis of KT activities. Similarly, Olmos-Peñuela et al (2014) and Ramos-Vielba et al. (2016) consider a broad range of KT activities, including direct personal interactions, informal cooperative relations and knowledge dissemination activities. These studies have generally found complementarities between KT activities, suggesting that they appear together, not in isolation (Grimpe and Hussinger, 2013; Siegel et al., 2003; Link et al., 2007).

Building upon the stream of the literature above, we consider both commercialisation (patenting, licensing and spin-offs) and "engagement in collaboration" (as mentioned above, joint and collaborative research contracts and consulting). We also include joint student supervision, external teaching, use of non-academic literature and participation in private seminars and conferences (informal relational activities) as the literature on KT in networks has shown these activities to play a crucial role (Uzzi, 1996, 1999; Hansen, 1999; Reagans and Zuckerman, 2001). Also, our study refers to the wider literature on external engagement and considers KT activities not only with industry but also with other types of external organisation, such as public administrations, non-profit organisations, and so on (Ramos-Vielba et al., 2016; Olmos-Peñuela et al., 2014; Sánchez-Barrioluengo, 2014).

We propose to distinguish this rich set of KT activities according to two main characteristics, which are important in terms of impact on KT. First, we expect the number of different KT activities (KT breadth) carried out by the scientist to matter. A higher number of KT activities implies the existence of more channels for KT, more modes of interaction with external organisation(s), which have been shown to generate KT more effectively. Thus, the presence of different channels for KT activity has been shown to increase a person's ability to convey complex ideas to diverse audiences (Reagans and McEvily, 2003). In a similar vein, Reagans and Zuckerman (2001) show that the interactions among scientists with non-overlapping networks outside of their team improve innovation and creativity by enhancing access to diverse knowledge. In addition, as stressed by D'Este and Patel (2007), academics using a broader range of KT channels are more likely to develop the capabilities necessary to bridge the gap between science and technological application, namely to favour "technology integration," because the variety of channels induces a higher diversity of the interacting knowledge bases and allows a better alignment of incentive systems between academia and the external environment. This argument can be extended to any type of external organisation with which the academics interact in their KT activities, be they public or private, because the diversity of knowledge bases and different incentive systems characterising the organisations still hold.

Second, we argue that not only the breadth but also the depth of KT channels (KT depth) matters for effective KT to take place. This refers to the frequency through which KT activity is conducted (i.e., the extent to which the relationship is repeated over time) and should also be relevant for the effectiveness of KT. Depth implies stronger ties, which have been shown to be more likely to ease the transfer of complex and tacit knowledge compared to weak ties (Granovetter, 1973; Uzzi, 1996, 1999). Frequent interactions improve the likelihood of developing complementarities between the knowledge bases of interacting individuals (Reagans and McEvily, 2003) as well as the creation of trust and reciprocity (Okada and Simon, 1997). The former literature has provided different explanations on how knowledge depth favours KT. A first class of explanations, which is grounded in cognitive and social psychology, contends that depth favours the development of associative learning and absorptive capacity (Cohen and Levinthal, 1990). Hence, depth is more likely to ease the development of problem-solving skills (Schmoch, 1999) and joint knowledge creation (Huber, 2013). A second set of explanations highlights the embeddedness of KT in social relations. More frequent interactions help in building social capital and developing shared norms and values. This in turn eases communication and understanding and therefore makes KT more effective (Uzzi, 1996; Hansen, 1999).

Since effective KT is expected to require depth and/or breadth of KT activities, the current work focuses on the motivation of academics for both of these dimensions of KT.

2.2. Motivations for knowledge transfer activities

Both the economics and psychology literatures have provided insights on motivations that can be useful in the study of engagement in KT activities. Both literatures have historically distinguished between intrinsic and extrinsic motivations. The former refers to motivation arising from internal factors (satisfaction, self-esteem, competence and pro-social behaviour)

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while the latter refers to motivation arising from external factors (monetary or other types of rewards, such as promotion, praise or reputation) (Deci and Ryan, 2002; Bénabou and Tirole, 2006).

Following the developments at the intersection of psychology and economics, different types of extrinsic and intrinsic motivations have been shown to influence the decisions of academics to engage with the external environment.

Among extrinsic motivations, monetary incentives have been found to motivate KT activities, especially those related to commercialisation (D'Este and Perkmann, 2011; Lam, 2011; Landry et al. 2007, Ramos-Vielba et al., 2016, Lee, 2000).

A second important category of extrinsic motivations for academics to engage with the external environment relates to learning motivations. The above refers to the possibility to access external expertise, develop new skills and exchange tacit knowledge, presumably to improve their findings and obtain high-impact publications. Several studies show that university faculty engage with the external environment mainly to obtain funding and get feedback on research (Lee, 2000; Katz and Martin, 1997; Bozeman and Corley, 2004). Similarly, in their study on UK engineering and physical scientists, D'Este and Perkmann (2011) find that research-related motivations (the possibility to learn from the knowledge exchange with external actors) are relevant for a rich set of KT activities.

A third category of extrinsic motivations, which has been observed and discussed in the literature, relates to reputational concerns (Perkmann et al., 2013, Link et al., 2007). As a key objective of academic scientists is recognition within the scientific community, which is also a prerequisite for career promotion, they might engage with the external environment to accumulate visibility within the wider scientific community.

The above three categories of motivation are essentially extrinsic in that they are related to an external reward. However, motivations often comprise both intrinsic and extrinsic elements, which are difficult to disentangle. Thus the above-mentioned learning motivation can be linked to external rewards (getting better publications, hence reputation and career prospects) and/or internal rewards (the pure satisfaction of feeling competent or "warm glow" as defined by Andreoni, 1989).

Pro-social motivations also have both intrinsic and extrinsic dimensions. Intrinsic motivations appear to be high among scientists since they have been shown to follow Mertonian norms of science: communality (common ownership of results), universalism (objectivity of scientific findings), disinterestedness (no self-interested motivations) and organised scepticism (detached scrutiny of beliefs in terms of empirical and logical criteria) (Merton, 1973). As a result, they derive satisfaction from the advancement of the overall body of knowledge in their discipline and the use of this knowledge to contribute to society at large.

In particular, a large part of academic scientists serves as civil servants who provide public services in the form of diffusion of new ideas and provision of higher education. The public administration literature shows that civil servants are mainly driven by an "alternative" orientation—represented by the notions of self-sacrifice, altruism and pro-social—in their motivation (Perry et al., 2010). This pro-social motivation is related to promoting the interests of the community or the nation, and "the desire to expand effort to benefit other people" (Grant, 2008, p. 49). It is expected to play a prominent role as a driver of KT activities among academics, since these activities aim at creating and diffusing new knowledge that in turn contributes to the development of the territory and wider society. This motivation may also carry an extrinsic element, if their contribution to the society at large leads to social recognition or praise that raises their reputation and possibly career prospects.

Lam (2011) considers intrinsic motivations in her analysis of the motivation of scientists to engage in commercialisation activities, relying on a sample of scientists from five major UK research universities working in the fields of biology, medicine, computer science, engineering and physical sciences. Building upon Stephan and Levin (1992), she classifies motivations for external engagement into three categories: "gold: (financial rewards), "ribbon" (reputational and career rewards) and "puzzle" (satisfaction derived from puzzle-solving activities but also from contributing to the knowledge of society). Her results provide evidence for a prominent role of "puzzle" and "ribbon" motivations: The scientists contained in her sample carry out KT activities with the primary purpose of developing their research and increase its impact on society.

In a similar vein, Ramos-Vielba et al. (2016) find that intrinsic motivations are important in their analysis of the motivations and barriers to scientific research groups' cooperation with firms and government agencies in Spain. They derive three categories of motivations: advancing research, which is related to accessing external networks as well as external

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equipment to favour the development of their research; applying knowledge, which is interpreted as an intrinsic impulse to apply knowledge and contribute to social, economic and technological problem-solving; and accessing financial resources, which is the extrinsic motivation of accessing external funding. As in Lam (2011), the intrinsic motivation (applying knowledge) category does not distinguish between the personal (personal satisfaction from resolving the research problem) and the social (doing good for the society at large, helping others) dimensions of intrinsic motivations.

Olmos-Peñuela et al. (2014) also study motivations for KT engagement by research groups, although their study is specifically focused on Social Sciences and Humanities. Like Ramos-Vielba et al. (2016), they find a strong correlation between the pro-social motivation (measured by the focus of research on issues which have a societal impact) of the research groups and their degree of KT engagement.

Overall, the literature points to the importance of analysing intrinsic motivations in more detail. Notably, we believe that distinguishing pure personal satisfaction, such as puzzle-solving activity, from pro-social motivations can provide a fruitful contribution. For example, the pure satisfaction of puzzle solving may be closely related to a scientist's personal gratification in feeling competent and in control, independently of social recognition or contribution to the society at large. The intrinsic motivation of academics in their KT activities might be therefore related to the (selfish) satisfaction of feeling able and competent and/or the contribution to the society at large (pro-social). This distinction is important because it is likely to lead to different impact of KT activities. On the one hand, scientists who are mainly motivated by altruistic motivations to engage with the external environment should be expected to be more concerned with the effective impact of their research in terms of knowledge creation and dissemination to external organisations. On the other hand, scientists who are mainly motivated by pure personal satisfaction will carry out KT activities in order to improve their own research with less emphasis on its applications and use in external organisations. In other words, pro-social motivations can be expected to be conducive to more effective KT and amelioration of techniques or products/services in external organisations.

2.3 Motivations for breadth and depth of knowledge transfer activities

Following the discussion on motivation for KT and the main results obtained by the former literature, we consider three main categories of motivations which we expect to be related to the breadth and depth of KT activities: (i) funding (the ability to obtain financial resources), (ii) learning (access to complementary competencies and knowledge or exchange of ideas) and (iii) mission (which reflects pro-social behaviour).

Although learning is likely to be a driver of both depth and breadth of KT activities, we expect it to have a more significant effect for KT depth. Scientists who are principally motivated by learning reasons to engage with the external environment are willing to establish long-term, deeply rooted and frequent connections with external agents as this is the setting which may be more conducive to learning opportunities. There is ample evidence in the literature on the role of frequent interactions as conduits of complex and tacit knowledge through the creation of a common knowledge base and a relationship of trust (see discussion in section 2.1).

A scientist engaging with the external environment for funding reasons can follow two main approaches. On the one hand, the scientist can aim to increase the number of channels through which he/she engages with external organisations (increase in KT breadth). On the other hand, the scientist can decide to interact more frequently with a reduced number of external parties (increase in KT depth) and aim to raise higher funds per external agent. Our expectation is then that funding motivation is associated with both the breadth and depth of KT activities.

Similarly, a scientist motivated by "mission" has two different strategies available. The first strategy is to reach out as many external agents as possible (the more the better). As different external partners tend to favour different KT channels (Olmos-Peñuela, 2014; Ramos-Vielba et al., 2016), the reliance on a plurality of channels can be fruitful as a way to convey research results to a wider audience. The second strategy refers to the willingness of the scientist to sustain a pattern of interaction over time to build up a shared understanding and common ways of working together with external agents. A deep understanding of common experience, norms, habits and routines is central to fine-tune expectations of scientists with a mission motivation for the interaction with external agents. This helps to build a common platform for interaction and favours "technology integration" as previously mentioned. Hence, we expect the funding and mission motivation to be associated with both frequent (breadth) and intense (depth) KT activities.

Nevertheless, there are reasons to expect a stronger effect of those two motivations on the KT depth rather than KT breadth. In fact, we contend that building frequent interactions for KT activities with external agents can be assimilated to a trust-building process, which is of the greatest importance both for funding and mission purpose. External agents are more willing to provide funds to academia when a relationship of trust is in place (Laursen et al., 2011). Similarly, scientists are more willing to interact with whomever has a credible commitment to the dissemination of scientific results (Bruneel et al., 2010). Such a trust relationship takes time to develop, and, for this purpose, more frequent interactions are better suited. Evidently, there is here an inherent "attention allocation problem" because of lack of time and effort on both sides (Simon, 1947; Penrose, 1959). In addition, both scientists and external organisations need to select and manage the external relationships. This is again a time-consuming process. It is then better to focus on a few deeply rooted relationships rather than running the risk of over-searching to increase variety.

Table 1 summarises the above discussion, clarifies the intersections between the two different categorisations and the single motivations and reports the foreseen relationship between the three motivations for KT and the breadth and depth of KT activities.

[INSERT Table 1 ABOUT HERE]

3. Data and methodology

3.1 Data

The sample used in this paper was extracted from an original database developed in 2009 following the research project TRACKs financed by the Autonomous Province of Trento. A survey was carried out to collect information on the KT activities of Italian scientists, by administering a structured questionnaire to a representative sample of academic researchers.[1] The questions concerned information on individual characteristics, motivations for and obstacles to carrying out KT activities and a full set of detailed mechanisms through which scientists interact with external agents.

[1]A careful preparatory phase consisted, at the beginning of 2009, of in-depth face-to-face interviews with the directors of three Technology Transfer Offices of three different Italian universities. All of the informants were interviewed once and were asked about the main themes that the research group intended to include in the questionnaire. The interviews lasted 45–60 minutes and were conducted by two persons, one asking questions and the other taking notes. The main purpose of these interviews was to: (i) collect preliminary information on KT activities in the Italian Higher Education System (MIUR), (ii) build a classification system of the different channels of KT through which Italian academics engage with the external environment and (iii) distinguish between formal and informal channels for KT. The results of this preliminary analysis were later used to design the questionnaire.

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Our starting point was a list containing names and affiliations of the population of Italian academics provided by the Italian Ministry of University and Education (MIUR). We then matched this list to a database containing information on the population of Italian academic inventors (CESPRI-PATSTAT), namely academics who have filed at least one patent in one major patent office during their career.[2] In this way, the population from which the target sample was extracted contained the full list of academic inventors working at Italian public universities.

A subset of 339 target academics was extracted from the resulting list, which included the following scientific disciplines: Life Sciences, Chemistry, Mathematics and Physics, Engineering and Medical Sciences. This subset was stratified according to the official categorisation of the field of science provided by the MIUR and academic position (assistant professor, associate professor and full professor). Between March and June 2009, the academics were contacted and asked to complete an online questionnaire relating to motivations for and obstacles to carrying out KT activities and a full set of detailed mechanisms through which scientists interact with external agents over the period 2004–2008, and 189 did so (response rate: 55.75%). In this study, we used records for which we were able to collect full information on the variables of interest. Therefore, the sample used in this paper includes 133 academics.[3]

As our starting population comprises only academic inventors, there is the concern that our analysis is biased towards the motivations leading to technology transfer, specifically via patenting activity. To control for this potential source of bias, we created a control sample of 61 academic scientists who were not academic inventors (academic non-inventors) and administered them a short version of the questionnaire (see the Appendix for details). Table A1 in the Appendix provides a comparison of the two samples (academic inventors used in the analysis and academic non-inventors). Interestingly, our original sample comprising academic inventors does not report relevant biases for the different motivations to carrying out KT activities. The strongest difference is found for the mission motivation (3 vs. 2.88 in

[2]Because the year of reference for CESPRI-PATSTAT is 2004, the list was updated using information from the MIUR website (affiliation, position, if retired or moved abroad, change of scientific field).

[3] A combination of non-response to the questionnaire (150) and missing information in the responses (56) has induced a bias in our sample. In particular, while response rates are generally similar across scientific fields (academic positions), chemical sciences (full professors) are overrepresented while medical sciences (assistant professors) are under-represented. A similar problem is found for gender, as male scientists are systematically over-represented. In order to control for the bias referring to these three main dimensions, we run a robustness check of our core results (Table 8) using post-stratification weights with respect to academic position, scientific field and gender. Results are robust to this further check and are available from the authors upon request.

favour of academic non-inventors), but this difference is only significant at the 10% level, with the value being higher for academic non-inventors, thus pointing in the worst-case scenario to an underestimation of our effect. More robust differences are instead found for the likelihood to engage in KT activities (other than patenting) and the percentage of time devoted to teaching and applied research. The percentage of time devoted to basic research and administrative tasks does not show any statistically significant difference between the two samples. Similarly, the scientific productivity (number of publications and number of citations) does not differ between the two groups of scientists.

3.2 Dependent variables and methods

As discussed in section 2, we are interested in examining the relationship between motivation to engage in KT activities and the different forms through which this interaction can be realised (KT breadth), as well as the intensity with which KT activities are carried out (KT depth).

The dependent variables are constructed using survey information on a large set of KT mechanisms. The respondents to our questionnaire were asked to rate the frequency of their interaction with the external environment through a number of different mechanisms during the period 2004–2008.[4] The different KT activities were consulting contracts (*Consulting contracts*), research contracts (*Research contracts*), joint research projects (*Joint research projects*), patent licences (*Licensing*), patents co-invented with non-University inventors (*Patents*), participation in the creation of spin-offs (*Spin-off*), supervision of post-doctoral students carrying out research activity in private companies (*Post-doctoral students*), use of external technical infrastructure (*Use of technical infrastructure*), teaching activity carried out in companies (*External teaching*), use of non-academic literature in one's own research (*Use of non-academic literature*), co-supervision of post-graduate theses (PGs) with external actors (*Joint supervision of PGs*), participation in corporate initiatives (conferences or workshops) (*Participation in initiatives*) and other more informal means of KT (such as telephone calls made with practitioners to solve specific research problems) (*Informal relational activities*). The two main dependent variables are then created following D'Este and Patel (2007) in their construction of the alternative measures of variety of University–industry interactions

[4]Building upon D'Este and Patel (2007), our respondents were asked to answer the following question for each type of KT activity: "How frequently did you engage in the following types of activity in the period 2004–2008?" The following scale was available for the answer: "0 times," "1-2 times', "3–5 times," "6–9 times," and "10 or more."

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(Variety 1 and Variety 2) and the construction of knowledge breadth and depth variables by Laursen and Salter (2006). This is done to incorporate two important dimensions in the KT process: (i) the number of different mechanisms through which KT is implemented (Variety 1 in the language of D'Este and Patel or knowledge breadth for Laursen and Salter) and (ii) The relative importance and extent of adoption of some mechanisms over others (Variety 2 for D'Este and Patel and knowledge depth for Laursen and Salter). Any measure of KT focused only on a subset of the above is likely to produce an incomplete picture of the phenomenon. For instance, focusing only on the number of different KT mechanisms can be an inadequate measure of KT if the different mechanisms are very similar or if one mechanism is very frequent and the rest extremely infrequent (D'Este and Patel, 2007).

KT breadth is constructed as a combination of the 13 KT activities noted above. As a starting point, each activity is coded as a binary variable, with 0 being no use and 1 being use of the given mechanism. Subsequently, the activities are simply added up so that each scientist receives a 0 when no activity is realised and 13 when all of the activities are realised. This measure has a good degree of internal consistency (Cronbach's alpha = 0.75).

KT depth is defined as the intensity with which scientists engage in the different types of KT activities. Accordingly, KT depth is constructed using the same 13 activities as those used in constructing KT breadth. In this case, each of the activities is coded as 1 when the scientist in question reports that he/she uses the activity to a high degree (i.e., 6 or more times in the period 2004–2008) and 0 otherwise. As in the former case, the 13 mechanisms are subsequently added up, so that each scientist receives a score of 0 when no mechanisms are frequently used and a score of 13 when all of the KT mechanisms are used to a high degree (Cronbach's alpha = 0.65).[5]

The two dependent variables are of a count type. The two models that are estimated can be written as

$$KT\ Breadth_i = \alpha_1 + \beta_1 Mission_i + \beta_2 Learning_i + \beta_3 Funding_i + \delta_s^T Z_i + \varepsilon_{1,i}$$

$$KT\ Depth_i = \alpha_2 + \beta_4 Mission_i + \beta_5 Learning_i + \beta_6 Funding_i + \delta_r^T Z_i + \varepsilon_{2,i}$$

[5]The two variables (KT breadth and KT depth) show a correlation of 0.55 which, even if not low, is in line with the correlation between other knowledge breadth and depth constructs found in other studies (Laursen and Salter, 2006; D'Este and Patel, 2007).

where $KT\ Breadth_i$ and $KT\ Depth_i$ indicate the two variables just described. *Mission*, *Learning* and *Funding* are the key explanatory variables; Z_i is a vector of scientist-specific control variables; and $\varepsilon_{1,i}$ and $\varepsilon_{2,i}$ are the error terms. Our preferred specification is a Poisson model estimated via quasi-maximum likelihood because it has been shown to provide consistent estimates of the coefficients of interest even when the underlying distribution of the dependent variable is not Poisson (Gourieroux, et al., 1984; Wooldridge, 1999). Moreover, the Poisson regression model has been shown to be robust to a number of misspecifications, such as over-dispersion (it can be accommodated by using robust standard errors), the presence of an excessive number of zeros, and dependence over time, as well as cross-sectional dependence (Bertanha and Moser, 2016). To take into account that decisions relating to KT depth and breadth are interrelated, we estimate the models using seemingly unrelated estimation which ensures that standard errors of the coefficients are properly computed (Laursen and Salter, 2014).[6]

3.3 Independent and control variables

The main independent variables refer to academics' motivation to engage with the non-academic environment: (i) acquisition of new knowledge for future research (*Learning*); (ii) broadening of the university mission (*Mission*) and (iii) funding new research activity (*Funding*). The three variables are built from responses to the following question contained in the survey: "Please rank the following motivations to engage with the non-academic environment according to their level of importance." The respondents were asked to rank the importance of each item on a four-point Likert scale, ranging from "not important" to "highly important." We run factor analysis on the 16 different items to synthesise the information in underlying common factors driving decisions to carry out KT activities.[7] The three resulting predicted factors (standardised to have a mean score of zero and standard deviation of one) are used as main explanatory variables in the econometric model. The results of the factor analysis are presented in Table 2. Note that different methods of factor extraction—principal

[6]We are grateful to one of the reviewers for pointing this out.

[7]The 16 items relating to motivation for involvement in interactions with the external environment contained in the question were 1) obtaining public research funding; 2) obtaining additional resources for basic research; 3) obtaining further resources for the research team; 4) access to complementary competencies; 5) strong predisposition to research; 6) exchange of ideas and experiences with industrial researchers; 7) on-site experience for institute staff and/or students; 8) gaining additional research insights in one's own area of research; 9) apply expertise to practical problems; 10) opportunity to see an application of one's own research findings; 11) securing good job prospects for students and/or institute staff in the business sector; 12) extending university mission; 13) promoting the diffusion of a particular technology; 14) diffusing key research findings amongst the public; 15) promoting local development and 16) improving the reputation of science.

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components, iterated principal factors and maximum likelihood—yield consistent results. The three measures have also a good degree of internal consistency (*Funding* Cronbach's alpha = 0.68; *Learning* Cronbach's alpha = 0.75; *Mission* Cronbach's alpha = 0.77). Previous literature assists in the interpretation of these three constructs (D'Este and Perkmann, 2011; Lam, 2011). The first factor includes items that involve learning opportunities in external engagement, such as "access to complementary competencies," but also "exchange of ideas" and the opening up of job prospects for staff or students. Accordingly, this factor is labelled *Learning*. The second group, *Mission*, contains a range of items that relate to the overall perceived usefulness of research for society at large, such as improving the reputation of science, extending the university mission and promoting local development. The third group relates to funding possibilities stemming from external interaction, particularly obtaining additional resources for the research team and for basic research. The corresponding group is labelled *Funding*. The motivation categories emerging from this empirical analysis therefore differ from those found in the previous literature. For example, while the "gold" category defined by Lam (2011) is similar to our category "Funding," her categories "puzzle" (inherent pleasure and satisfaction in doing research) and "ribbon" (recognition among peers) differ from our learning and mission categories: the former is more directly linked to the possibility of accessing the external organisation's knowledge base and having more learning potential (through the exchange of ideas and experiences, accessing a complementary knowledge base that helps resolve the research issue, thereby providing additional research insights which denote both intrinsic—the personal satisfaction derived from research activity—and extrinsic––improving publication activity—motivations), while the latter (*Mission*) is more directly linked to the idea of contributing, through KT activities, to the society at large, witnessing to the practical application of own research, benefits to external organisation, extending the university mission and contributing to local development, and is hence a pro-social motivation.

[INSERT Table 2 ABOUT HERE]

We seek to minimise any problem of omitted variable bias by including a set of controls in the econometric specification. We include *Age*, which controls for age effects on the frequency of external engagement; *Gender* is a dummy variable taking the value 1 if the scientist is a male and 0 if she is a woman. We also control for the amount of research funding that the academic scientist is able to attract because previous literature has shown that this funding can be an important determinant of the intensity of external engagement

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(Gulbrandsen and Smeby, 2005). *Public Funding* is the share of public funding obtained by the scientist for research over the total amount of funding received by all academics in the same scientific field during the period 2004–2008.[8] The variable *Research Quality* controls for the quality of scientific production of the scientist because more productive scientists are likely to be more attractive to external partners and thus should present a higher degree of interaction. This variable is built using the Journal Citation Reports published annually by the Institute for Scientific Information (ISI). ISI ranks journals by impact factor (JIF) in different scientific fields. We weight each article published by the academics in our sample by the corresponding journal's impact factor, sum these weights for all of the published output in the period 2004–2008 and divide by the publication count in the given period. The resulting variable is taken to be a measure of quality for the average article published by one of our scientists in the given period (Azoulay et al., 2009).[9] Following the classification provided by the MIUR, we also included five dummies controlling for the following scientific fields: Life Sciences, Chemistry, Mathematics and Physics, Engineering and Medical Sciences. The geographical location of the university (*Geographical*)[10] is also taken into account because the substantial difference in development between the North and the South of Italy is likely to influence academics' external engagement. Table 3 provides descriptive statistics of the variables, while Table 4 reports the correlation matrix for the covariates. Correlation across the independent variables is low, suggesting the absence of any relevant problems of multi-collinearity.[11]

[INSERT Table 3 AND Table 4 ABOUT HERE]

4. Results

4.1 Descriptive results

Table 5 provides the distribution of academics contained in our original sample across a full set of mechanisms for external interaction. Column 1 of Table 5 shows the distribution for

[8]Public research funding refers to the funding obtained under the public Italian competitive programme "Research Projects of National Interest (PRIN)" and financed by the Italian Ministry for University and Research (MIUR). During the period of reference, PRIN was one of the most important national sources of funding for public research.

[9]As robustness check, we also used the average number of citations received by the articles published by the scientist over the period 2004–2008. Results do not qualitatively differ from those presented here. Results are available from the authors upon request.

[10]Geographical areas refer to the following categories: (i) North, (ii) Center and (iii) South and islands.

[11]This has been confirmed by the computation of the variance inflation factor which has a mean value of 1.57 (ranging between 1.06 and 2.83).

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academic scientists who engaged at least once in that activity over the period 2004–2008. Column 2 in the same table shows the distribution for those who frequently (more than six times) engaged in the activity in the period 2004–2008.

Table 5 shows that contract-based and informal means of KT (e.g., use of non-academic literature, research contracts, participation in corporate initiatives) are a frequent KT activity among the university academics in our sample. Indeed, as Table 5 shows, these arrangements are more frequently used than more formal (and widely studied) KT channels, such as licences and spin-offs.[12]

It is also notable that in the analysis of recurrent interactions (column 2 in Table 5), the proportion of active academics is considerably lower compared with that of simple engagement (never above 25%). Moreover, the two columns indicate a change in the relative importance of several items. For example, although research contracts represent an important channel of external interaction (more than 66% of academics used this mechanism in the reference period), they do not represent a frequent mode of interaction (only 10% of academics claim to have used this channel six times or more in the period 2004–2008). Similarly, while more than 87% of the academics in our sample engaged with non-academic partners by reading and citing non-academic literature, only 5% of them do so frequently. These differences point to two diverse modes of external interaction: (i) engagement via a range of KT activities (KT breadth) and (ii) recurrent engagement with external partners through a selected number of KT activities (KT depth).

[INSERT Table 5 ABOUT HERE]

Table 6 and Table 7 provide the correlation matrix of items reported in columns 1 and 2 of Table 5, respectively. The correlation among different channels is always low, so that the different typologies of KT engagement do not appear to overlap in our sample.

[INSERT Table 6 AND Table 7 ABOUT HERE]

[12]This finding does not apply to the patent mechanism but is the mere result of the design of the sample which, as discussed in section 3.1, starts from the population of Italian academic inventors. Although the "patenting" item bears no variation for the KT breadth variable, it conveys relevant information for the depth of KT activities (i.e., about 13% of scientists in our sample filed a patent six or more times during the period 2004–2008). As a robustness check for our results on KT breadth, we re-run the estimates dropping the "patenting" item. Results do not differ from those presented here and are available from the authors upon request.

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4.2 Econometric results

Table 8 presents our core results concerning the relationship between the three main academic motivations to engage with the external environment (*Learning*, *Funding* and *Mission*) and KT activities. In a first specification (Model 1) we present results for an aggregated measure of external engagement. Following recent contributions (Tartari et al., 2014; Tartari and Salter, 2015), we have built an academic engagement index that combines the two key aspects of KT breadth and depth: the variety of forms of engagement and the intensity of collaboration.[13] Models 2a and 2b of Table 8 refer closely to the model depicted in section 3.2 and show estimates for *KT Breadth* and *KT Depth* separately. In this way, we are able to show whether there are meaningful differences in the role of motivations for KT breadth or depth, compared to an aggregated measure.

Regarding controls, we observe that the coefficient of the *Gender* variable is positive and significant for all variables [Academic Engagement Index (*AEI*), *KT Breadth* and *KT Depth*]. Male scientists therefore appear more likely to engage with external partners than women. This finding can also indicate a gender bias in engagement in KT activities, in line with similar results showing a gender gap in patenting (Ding et al., 2006), grant applications (Ley and Hamilton, 2008) and external engagement in general (Tartari and Salter, 2015). The propensity to obtain public funding for research seems to be an important driver for academic engagement (Model 1 in Table 8). Interestingly, when KT breadth and depth are investigated separately, the coefficient of *Research Funding* is positive and strongly significant at standard confidence levels for the depth of KT activities only. This result indicates a significant complementarity between the ability to raise public funds for research and the intensity of external engagement, providing further support for similar findings in the recent literature relating faculty quality to industry involvement in technology-oriented disciplines (Perkmann and Walsh, 2009: Perkmann et al., 2011). Working in an engineering field exhibits a positive and significant correlation with all variables (AEI as well as the breadth and depth of KT activities). This finding resonates with the evidence that applied fields of science engage more actively with the external environment through a variety of channels (D'Este et al., 2013). Finally, we find no significant correlation between academic engagement and scientific productivity. This result is in line with the mixed findings in the literature studying the

[13]For a detailed description of how the index has been calculated, refer to Tartari et al. (2014) and Tartari and Salter (2015). The estimation method used is ordinary least squares (OLS).

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relationship between academics' research productivity and engagement in KT activities (Azoulay et al., 2009; Rentocchini et al., 2014).

Regarding motivations, in the first specification with the aggregated measure of academic engagement, both *Mission* and *Funding* show a positive and highly significant correlation (at the 1% level) with no significant effect of *Learning*. Even more importantly for our analysis, *Mission* and *Funding* show a positive and highly significant correlation (at the 1% level) with both *KT Breadth* and *KT Depth* (Models 2a and 2b in Table 8). The coefficient of *Learning* is found to be non-significant for *KT Breadth* and *KT Depth*. The "mission" motivation, together with the "funding" one, thus appears of primary importance: The academics contained in our sample may feel particularly invested in the third mission of their university, and this investment can eventually spur the expansion of the breadth and depth of their external engagement. This result suggests a pro-social motivation to engage with external partners by academic scientists that has been mainly overlooked by the existing literature, namely academics' willingness to contribute to the economic and social development of the region or wider society. The motivation related to funding is found to be equally important for academics' external engagement because we are unable to reject the test on the difference between the coefficients of *Mission* and *Funding* for both *KT breadth* ($\chi^2[1] = 2.05$; p value = 0.1523) and *KT depth* ($\chi^2[1] = 0.04$; p value = 0.8450). Even more interestingly, and in line with the theoretical argument developed in section 2.3, *Mission* and *Funding* appear more relevant for *KT depth* than *KT breadth* ($\chi^2[1] = 4.26$; p value = 0.03; $\chi^2[1] = 15.99$; p value = 0.0001). Both effects are also meaningful from an economic perspective: One standard deviation increase in *Mission* (*Funding*) yields an increase of 36.7% (39.7%) in the expected number of frequent KT activities (*KT depth*), compared with an increase of 13% (7%) in the expected number of KT activities (*KT breadth*).

Despite the reliability of the model presented above, further robustness checks have been carried out. First, a negative binomial regression has been performed to control whether the estimated coefficients are biased due to a problem of over-dispersion (conditional expected values of *KT Breadth* and *KT Depth* are relatively far from their conditional variance). Second, a zero inflated Poisson model (Cameron and Trivedi, 1998) has been estimated to account for the relatively high number of zeros characterising *KT Depth*. Building upon Laursen and Salter (2014), we have also transformed *KT depth* and *KT breadth* in fractional variables by dividing them by an upper bound (their sample maximum) and applying

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fractional logit regressions. Our main results are confirmed for all of the robustness checks noted above (see Table 9).

5. Conclusion

Since university has been seen as an institution with a plurality of goals, not only an ivory tower but also an engine of economic growth (Florida and Cohen, 1999) which systematically collaborates with external actors, many studies analysed the motivations for which academic scientists are involved in KT activities (D'Este and Perkmann, 2011; Lam, 2011; Sánchez-Barrioluego, 2014; Tartari et al., 2014; Ramos-Vielba et al., 2016). The identification of such motivations and the understanding of their relevance are important, not only from a purely cognitive point of view, but also to implement adequate policies.

This paper analyses the link between different motivations for academic scientists to engage in KT activities and the degree, in terms of "breadth" (variety) and "depth" (frequency) of their involvement. As called for by Perkmann et al. (2013), we develop a conceptual framework drawing upon findings from the KT and social network literatures (Granovetter, 1973; Okada and Simon, 1997), as well as psychological and economics studies of motivations, particularly pro-social ones (Deci et al., 1999, Deci and Ryan, 2002; Andreoni, 1989; Bénabou and Tirole, 2006).

A first descriptive result of our study is that the academics in our sample appear, in their engagement with the external environment, to adopt two alternative strategies: either they engage in a variety of different KT activities or they focus on a relatively smaller number of channels with a higher frequency. This resonates well with the findings from streams of literature on social networks and KT activities, which have shown that both the variety and intensity of relationships lead to higher exchange and creation of knowledge and eventually to a more effective transfer of knowledge (Hansen, 1999; Nooteboom, 2000).

Most notably, our study, while confirming that academics are driven by a mix of extrinsic (deriving from external factors, such as pecuniary or career rewards) and intrinsic (deriving from internal factors, such as personal satisfaction, self-esteem, competence) motivations when participating in KT processes with non-academic partners (Lam, 2011; D'Este and Perkmann, 2011; Ramos-Vielba et al., 2016; Olmos-Peñuela et al., 2014), reveals an

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important role played by pro-social motivations (denominated as "Mission") in driving academics in their KT activities (in their breadth and depth dimensions).

The former literature has mainly focused on financial and learning motivations. Financial motivation, typically extrinsic, refers to the direct or indirect financial rewards linked with these activities. In our study, this financial motivation ("Funding") emerges as an important driver of KT engagement by academics. Learning motivation is related to the possibility to access external expertise and competences as well as to exchange ideas and knowledge with the external environment. For this motivation, we find a positive but not significant effect on breadth and depth of KT activities.

Besides funding and learning motivation, we also identify the pro-social or mission motivation. It mainly relates to the possibility to commit to society at large by contributing to the development of organisations they engage with and to the local economic and social well-being. Such motivation has a marked extrinsic component, without excluding an intrinsic part, consisting of the prospects of possible improvements in career at the individual level that may derive from such activity of science dissemination. The results of our study points to the importance, in driving KT engagement, of pro-social motivations: We find that the "mission" motivation has a significant positive effect on both KT breadth and depth. This suggests that a large number of academics have a strong interest in contributing to the society at large and this favours KT between universities and external organisations, in terms of both intensity and variety of channels.

It is also noteworthy that in line with our expectations, both funding and mission motivation have a stronger effect on KT depth than on KT breadth: Frequent interactions are needed to build trust in relationships, which is important both for providing funds to academia and for disseminating scientific results.

It is worth noticing that our results might be related to the characteristics of external organisations in Italy, be they partners from industry or other types of organisations (e.g., public administrations, non-governmental organizations, professional associations). In fact, a result of the literature is that the type and level of interaction between academia and the external environment is strongly dependent on firm size and the sectors in which the firms operate (Laursen and Salter, 2004; Mohnen and Hoareau, 2003). The Italian industrial structure is characterised by the presence of SMEs operating in traditional manufacturing

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sectors, particularly in industrial districts (Harrison, 2007). According to Rizzo (2014), scientists willing to get involved in KT activities with SMEs are driven primarily by the desire to make a contribution to the wider society.

The peculiarity of the Italian case may also help to explain the weak role played by learning motivation to engage with the external environment. On the one hand, as SMEs tend to specialise in specific and limited knowledge bases, they are likely to benefit from knowledge coming from university, but the learning opportunities for academics are likely to be narrow. Similarly, firms in industrial districts have been shown to interact less with universities than larger firms (Muscio, 2006a). On the other hand, regarding other types of external organisations (e.g., non-profit organisations, public administrations), learning opportunities in KT activities are likely to be limited by the weaknesses of public administrations, which are often characterised by a high degree of rigidity and by a predominance of bureaucratic formalism rather than a dynamic attitude to favour economic development in modern ways (Galanti, 2011). As highly hierarchical organisation structures inhibit or slow down most sharing practices, KT for learning purposes can be severely hampered (Riege, 2005).

On the basis of these results, it follows that the policy action by policy makers, university managers and technology transfer officers aiming at stimulating external engagement should not only focus on "financial" incentives but also on the "mission" motivation, its link with the territory and the immediate contribution to improving people's lives. For this purpose, initiatives should create opportunities for contacts and knowledge exchange between universities and other organisations, so as to improve the complementarity of the knowledge bases, the alignment of incentives as well as the absorptive capacity of the partners. A focus could be on organisations located in the local areas, because proximity promotes the establishment of collaboration agreements, particularly with industrial districts, which largely characterise the Italian economic system (Muscio et al., 2012). Intrinsic motivations cannot be enforced, but can be strengthened by these socialisation initiatives, as well as increasing resources to pursue research at university so that the knowledge base to be transferred can be widened.

The paper has limitations that open up avenues for future research. First, the results might be altered if other countries were also included. Second, a methodological warning is needed: Although our analysis is based on variables which are eminently time-invariant (motivation of academic scientists to engage with the external environment), the cross-sectional nature of our data, together with the absence of a pure experimental setting, suggests caution when interpreting the results in a causal way. Finally, our estimation sample is biased towards researchers located in the North of Italy; this should be considered in the possibility to generalise our results.

Despite these limitations, we believe that this work is but a preliminary step in an arguably promising trajectory. Greater understanding of specific motivations for academic external engagement may provide further insights on policy and managerial issues concerning university external engagement, the fine-tuning of appropriate systems of incentives to spur the "third mission" of universities and the role of education policy in responding to emergent industry needs.

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References

Abreu, M., Grinevich, V. (2013). The nature of academic entrepreneurship in the UK: widening the focus on entrepreneurial activities. Research Policy, 42, 408-422.

Andreoni, J. (1989). Giving with impure altruism: applications to charity and Ricardian equivalence. Journal of Political Economy, 97, 1447-58.

Azoulay, P., Ding, W., Stuart, T. (2009). The impact of academic patenting on the rate, quality and direction of (public) research output. Journal of Industrial Economics, 57, 637-676.

Bekkers, R., Bodas Freitas, I.M. (2008). Analysing knowledge transfer channels between universities and industry: to what degree do sectors also matter? Research Policy, 37, 1837-1853.

Bénabou, R., Tirole, J. (2006). Incentives and prosocial behavior. American Economic Review, 96, 1652-1678.

Bertanha, M., Moser, P. (2016). Spatial errors in count data regressions. Journal of Econometric Methods, 5, 49-69.

Bozeman, B., Corley, E. (2004). Scientists' collaboration strategies: implications for scientific and technical human capital. Research Policy, 33, 599-616.

Bruneel, J., d'Este, P., Salter, A. (2010). Investigating the factors that diminish the barriers to university–industry collaboration. Research Policy, 39, 858-868.

Cameron A.C. and Trivedi P.K. (1998). Regression analysis of count data. Cambridge University Press, New York.

Cohen, W., Levinthal, D. (1990), Absorptive capacity: A new perspective on learning and innovation. Administrative Science Quarterly, 3, 128-152.

Dechenaux, E., Thursby, J., Thursby, M. (2011). Inventor moral hazard in university licensing: the role of contracts. Research Policy, 40, 94-104.

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Research Policy 46(2), pp. 497-509, 2017
https://doi.org/10.1016/j.respol.2016.12.003

Deci, E.L., Koestner, R., Ryan, R.M. (1999). A meta-analytic review of experiments examining the effects of extrinsic rewards on intrinsic motivation. Psychological Bulletin, 125, 627–668.

Deci, E., Ryan, R. (Eds.), (2002). Handbook of Self-determination Research. University of Rochester Press, Rochester, NY.

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

D'Este, P., Perkmann, M. (2011). Why do academics engage with industry? The entrepreneurial university and individual motivations. Journal of Technology Transfer, 36, 316-339.

D'Este P., Llopis O., Yegros A. (2013). Conducting prosocial research: cognitive diversity, research excellence and awareness of the social impact of research. 35th DRUID Celebration Conference 2013, Barcelona, Spain, June 17-19.

Ding W. W., Choi E. (2011). Divergent paths to commercial science: a comparison of scientists' founding and advising activities. Research Policy, 40, 69-80.

Ding W.W., Murray F., Stuart T.E. (2006). Gender differences in patenting in the academic life sciences. Science, 313(5787), 665-667.

Etzkowitz, H. (2003). Research groups as 'quasi-firms': the invention of the entrepreneurial university. Research Policy, 32, 109–121.

Etzkowitz, H., & Leydesdorff, L. (2000). The dynamics of innovation: from National Systems and "Mode 2" to a Triple Helix of university–industry–government relations. Research Policy, 29, 109-123.

Etzkowitz, H., Webster, A., Gebhardt, C., Terra, B.R.C. (2000). The future of the university and the university of the future: evolution of ivory tower to entrepreneurial paradigm. Research Policy, 29, 313-330.

European Commission (1995). Green Paper on Innovation, Bruxelles.

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Research Policy 46(2), pp. 497-509, 2017
https://doi.org/10.1016/j.respol.2016.12.003

European Commission (2007). Improving knowledge transfer between research institutions and industry across Europe: embracing open innovation. Implementing the Lisbon agenda, Luxembourg, Office for Official Publications of the European Community.

Florida, R., Cohen, W.M. (1999). Engine or infrastructure? The university role in economic development, in: Branscomb, L.M., Kodama, F., Florida, R. (Eds.), Industrializing Knowledge: University-Industry Linkages in Japan and the United States. MIT Press, Cambridge, pp.589-610.

Galanti, M.T. (2011). Is Italian bureaucracy exceptional? Comparing the quality of Southern European public administration. Bulletin of Italian Politics, 3(1), 5-33.

Gourieroux, C., Monfort, A., Trognon, A. (1984). Pseudo maximum likelihood methods: theory. Econometrica: Journal of the Econometric Society, 681-700.

Granovetter, M.S. (1973). The strength of weak ties. American Journal of Sociology, 78, 1360-1380.

Grant, A.M. (2008). Does intrinsic motivation fuel the prosocial fire? Motivational synergy in predicting persistence, performance, and productivity. Journal of Applied Psychology, 93, 48.

Grimpe, C., Fier, H. (2010). Informal university technology transfer: a comparison between the United States and Germany. Journal of Technology Transfer, 35, 637-650.

Grimpe, C., Hussinger, K. (2013). Formal and informal knowledge and technology transfer from academia to industry: complementarity effects and innovation performance. Industry and Innovation, 20, 683-700.

Gulbrandsen, M., Smeby, J.C. (2005). Industry funding and university professors' research performance. Research Policy, 34, 932-950.

Hansen, M.T. (1999). The search-transfer problem: the role of weak ties in sharing knowledge across organization subunits. Administrative Science Quarterly, 4, 82-111.

Harrison, B. (2007). Industrial Districts: Old Wine in New Bottles? (Volume 26, Number 5, 1992). Regional Studies, 41(S1), S107-S121.

Hsu, D. W., Shen, Y. C., Yuan, B. J., & Chou, C. J. (2015). Toward successful commercialization of university technology: performance drivers of university technology transfer in Taiwan. Technological Forecasting and Social Change, 92, 25-39.

Huber F. (2013). Knowledge-sourcing of R&D Workers in Different Job Positions: contextualising External Personal Knowledge Networks. Research Policy, 42, 167-79.

Jensen, R.A., Thursby, M.C. (2001). Proofs and prototypes for sale: the licensing of university inventions. American Economic Review, 91, 240–259.

Katz, J.S., Martin, B.R. (1997). What is research collaboration? Research Policy, 26, 1-18.

Lam, A. (2011). What motivates academic scientists to engage in research commercialisation: 'gold', 'ribbon' or 'puzzle'?. Research Policy, 40, 1354-68.

Landry, R., Amara, N., Ouimet, M. (2007). Determinants of knowledge transfer: evidence from Canadian university researchers in natural sciences and engineering. Journal of Technology Transfer, 32, 561-592.

Landry, R., Saïhi, M., Amara, N., & Ouimet, M. (2010). Evidence on how academics manage their portfolio of knowledge transfer activities. Research Policy, 39, 1387-1403.

Laursen, K., Reichstein, T., Salter, A. (2011). Exploring the effect of geographical proximity and university quality on university–industry collaboration in the United Kingdom. Regional Studies, 45, 507-523.

Laursen, K., Salter, A. (2004). Searching high and low: what types of firms use universities as a source of innovation?. Research Policy, 33, 1201–1215.

Lee, Y. (2000). The sustainability of university-industry research collaboration: an empirical assessment. Journal of Technology Transfer, 25, 111-133.

Ley, T. J., Hamilton, B.H. (2008). The gender gap in NIH grant applications. Science, 322 (5907), 1472-1474.

Leydesdorff, L., Etzkowitz, H. (1996). Emergence of a Triple Helix of university-industry-government relations. Science and public policy, 23, 279-286.

Link, A.N., Siegel, D.S., Bozeman, B. (2007). An empirical analysis of the propensity of academics to engage in informal university technology transfer. Industrial and Corporate Change, 16, 641-655.

Link, A.N., Scott, J.T. (2012). Public Accountability: evaluating Technology-Based Institutions. Springer Science & Business Media.

Merton, R. (1973). The Sociology of Science. University of Chicago Press, Chicago.

Moog, P., Werner, A., Houweling, S., Backes-Gellner, U. (2015). The impact of skills, working time allocation and peer effects on the entrepreneurial intentions of scientists. Journal of Technology Transfer, 40, 493-511.

Muscio, A. (2006). Patterns of innovation in industrial districts: an empirical analysis. Industry and Innovation, 13, 291–312.

Muscio A., Quaglione D., Scarpinato M. (2012). The effect of universities' proximity to industrial districts on university-industry collaboration. China Economic Review, 23, 639-650.

Nooteboom, B. (2000). Learning by interaction: absorptive capacity, cognitive distance and governance. Journal of Management and Governance, 4, 69-92.

OECD (2002a). Benchmarking industry–science relationships, Paris.

OECD (2002b). Special issue on fostering high-tech spin-offs: a public strategy for innovation. OECD review No. 26.

Okada, T., Simon, H.A. (1997). Collaborative discovery in a scientific domain. Cognitive Science, 21, 109-146.

Olmos-Peñuela, J., Castro-Martínez, E., D'Este, P. (2014). Knowledge transfer activities in social sciences and humanities: explaining the interactions of research groups with non-academic agents. Research Policy, 43, 696-706.

Owen-Smith, J., Powell, W.W. (2001). Careers and contradictions: faculty responses to the transformation of knowledge and its uses in the life sciences. Research in the Sociology of Work, 10, 109–140.

Penrose, E.T. (1959). The Theory of the Growth of the Firm. John Wiley, New York.

Perkmann, M., Tartari, V., McKelvey, M., Autio, E., Broström, A., D'Este, P., Fini, R., Geuna, A., Grimaldi, R., Hughes, A., Krabel, S., Kitson, M., Llerena, P., Lissoni, F., Salter, A., Sobrero, M. (2013). Academic engagement and commercialisation: a review of the literature on university–industry relations. Research Policy, 42, 423-442.

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

Perry, J.L., Hondeghem, A., Wise, L.R. (2010). Revisiting the motivational bases of public service: twenty years of research and an agenda for the future. Public Administration Review, 70, 681-690.

Ramos-Vielba, I., Sánchez-Barrioluengo, M., Woolley, R. (2016). Scientific research groups' cooperation with firms and government agencies: Motivations and barriers. Journal of Technology Transfer, 41, 558-85.

Reagans, R., McEvily, B. (2003). Network structure and knowledge transfer: The effects of cohesion and range. Administrative Science Quarterly, 48, 240-267.

Reagans, R., Zuckerman, E. (2001). Networks, diversity and performance: The social capital of R&D units. Organization Science, 12, 502-517.

Rentocchini, F., D'Este, P., Manjarrés-Henríquez, L., Grimaldi, R. (2014). The relationship between academic consulting and research performance: Evidence from five Spanish universities. International Journal of Industrial Organization, 32, 70-83.

Riege, A. (2005). Three-dozen knowledge-sharing barriers managers must consider. Journal of Knowledge Management, 9, 18-35.

Rizzo, U. (2014). Why do scientists create academic spin-offs? The influence of the context. Journal of Technology Transfer, 40, 198-226.

Rothermael, F.T., Agung, S.D., Jian, L. (2007). University entrepreneurship: a taxonomy of the literature. Industrial and Corporate Change, 16, 691-792.

Sánchez-Barrioluengo, M. (2014). Articulating the 'three missions' in Spanish universities. Research Policy, 43, 1760-1773.

Schmoch, U. (1999). Interaction of universities and industrial enterprises in Germany and the United States-a comparison. Industry and Innovation, 6, 51-68.

Shane S., Stuart T. (2002). Organisational endowments and the performance of university start-ups. Management Science, 48, 154-170.

Siegel D., Wright M., Lockett A. (2007). The rise of entrepreneurial activity at universities: organizational and societal implications. Industrial and Corporate Change, 16, 489-504.

Simon H.A. (1947) Administrative Behavior. Macmillan, New York.

Stephan, P.E., Levin, S.G. (1992). Striking the Mother Lode in Science: the Importance of Age. Oxford University Press, Oxford.

Tartari, V., Perkmann, M., Salter, A. (2014). In good company: the influence of peers on industry engagement by academic scientists. Research Policy, 43, 1189-1203.

Tartari, V., Salter, A. (2015). The engagement gap: exploring gender differences in University–Industry collaboration activities. Research Policy, 44, 1176-1191.

Thursby, J.G., Thursby, M.C. (2002). Who is selling the ivory tower? Sources of growth in university licensing. Management Science, 48, 90-104.

Uzzi, B. (1996). The sources and consequences of embeddedness for the economic performance of organizations: the network effect. American Sociological Review, 61, 674-698.

Uzzi, B. (1999). Social relations and networks in the making of financial capital. American Sociological Review, 64, 481-505.

Wooldridge, J. M. (1999). Distribution-free estimation of some nonlinear panel data models. Journal of Econometrics, 90, 77-97.

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Table 1: Expected relationships between motivations and breadth and depth of KT activities

Motivation for KT	**Description**	**Category**	**Expected effect on depth**	**Expected effect on breadth**
Funding	Financial compensation of the activity	Extrinsic	High	Medium
	Career prospects raised by reputation building induced by the KT activity	Extrinsic		
Learning	Improvement of a "scientist's" own research due to access to complementary expertise and exchange of ideas	Extrinsic	High	Medium
	Satisfaction from improvement in one's own research (warm glow)	Intrinsic		
Mission (pro-social)	Improved reputation or praise from contribution to society at large	Extrinsic	High	Medium
	Pure satisfaction from contributing to society at large	Intrinsic		

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Table 2: Factor analysis of motivations

		Principal components			**Maximum likelihood**			**Iterated principal factors**		
		Factor1	*Factor2*	*Factor3*	*Factor1*	*Factor2*	*Factor3*	*Factor1*	*Factor2*	*Factor3*
Funding	Additional resources for basic research	**0.8614**	0.0028	0.1287	**0.5084**	0.0285	0.1667	**0.7003**	0.015	0.1343
	Further resources for the research team	**0.8024**	0.2102	0.183	**0.9741**	0.1896	0.1233	**0.702**	0.2073	0.1817
Learning	Access to complementary competences	0.0893	**0.7231**	-0.0325	0.0091	**0.5692**	0.0751	0.0687	**0.5957**	0.0482
	Strong predisposition to research	-0.063	**0.461**	0.272	0.0541	**0.3675**	0.2677	0.0067	**0.37**	0.2625
	Exchange of ideas and experiences	0.1612	**0.6696**	-0.0018	0.0799	**0.5709**	0.0897	0.1139	**0.549**	0.0758
	On-site experience for staff and/or students	0.1045	**0.784**	0.1968	0.0881	**0.7958**	0.1869	0.1019	**0.7785**	0.2002
	Additional research insights	-0.0208	**0.6285**	0.2273	0.0555	**0.523**	0.2338	0.0183	**0.5345**	0.2427
	Job prospects for students/staff	0.1273	**0.5214**	0.2987	0.1875	**0.4417**	0.2722	0.1194	**0.4513**	0.2939
Mission	Apply one's own expertise to practical problems	-0.165	0.4397	**0.5067**	-0.0475	0.3914	**0.4574**	-0.0763	0.3966	**0.4598**
	See application of research findings	0.015	0.4153	**0.4639**	0.1212	0.3634	**0.3907**	0.061	0.3728	**0.414**
	Extending university mission	0.2088	0.1859	**0.6286**	0.1479	0.2046	**0.5587**	0.1818	0.2036	**0.5543**
	Diffusion of a particular technology	0.0887	0.1018	**0.6338**	0.0973	0.1944	**0.4766**	0.1026	0.1518	**0.5098**
	Diffusing key research findings	0.1814	0.1262	**0.6702**	0.1409	0.1678	**0.5702**	0.173	0.1546	**0.5827**
	Promoting local development	-0.0053	0.1414	**0.61**	0.0684	0.1695	**0.5188**	0.0391	0.1662	**0.5027**
	Improving the reputation of science	0.1183	0.0389	**0.7592**	0.1244	0.0304	**0.7343**	0.1298	0.0499	**0.7085**
	Cumulative % variance explained	0.1981	0.3953	0.5004	0.198	0.3045	0.6362	0.1081	0.2433	0.6843

The Rotation method is Varimax with Kaiser normalisation. Bold numbers indicate to which factor the item was assigned. We used 50% of cumulative variance explained as a stopping criterion.

Table 3: Descriptive statistics (n=133)

Variable	Mean	Median	Std. dev.	Min	Max
Dependent variables					
Academic Engagement Index (AEI)	8.35	6.522	6.543	0.045	30.03
KT breadth	7.421	8	2.783	2	13
KT depth	1.22	1	1.5	0	6
Independent variables					
Learning	3.19	3.33	0.489	2	4
Mission	2.88	2.86	0.542	1.57	4
Funding	2.89	3	0.766	1	4
Control variables					
Gender	0.827	1	0.380	0	1
Age	57.526	58	8.561	40	78
Research quality	2.503	2.58	1.325	0	6.94
Public funding	0.020	0	0.058	0	0.368
Geographical dummies					
South	0.180	0	0.386	0	1
North	0.602	1	0.491	0	1
Centre	0.218	0	0.414	0	1
Scientific discipline					
Biological Sciences	0.165	0	0.373	0	1
Chemical Sciences	0.406	0	0.493	0	1
Mathematics & Physics	0.045	0	0.208	0	1
Engineering	0.293	0	0.457	0	1
Medical Sciences	0.090	0	0.288	0	1

The independent variables (Mission, Learning and Funding) are reported with unstandardised values.

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Table 4: Correlation matrix of independent and control variables

		[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	[10]	[11]	[12]	[13]	[14]
[1]	Funding	1													
[2]	Learning	0.24	1												
[3]	Mission	0.29	0.51	1											
[4]	Gender	-0.14	-0.09	-0.08	1										
[5]	Age	0.01	-0.09	0.03	0.36	1									
[6]	Research quality	0.05	0.00	0.00	-0.27	-0.05	1								
[7]	Public funding	-0.02	0.07	0.13	0.08	0.21	0.01	1							
[8]	South	0.14	0.08	0.11	-0.04	-0.08	0.09	-0.09	1						
[9]	North	-0.19	-0.01	-0.18	0.16	0.00	-0.16	-0.12	-0.58	1					
[10]	Centre	0.10	-0.06	0.11	-0.14	0.08	0.10	0.23	-0.25	-0.65	1				
[11]	Biological Sciences	-0.14	-0.10	-0.09	-0.01	0.06	0.23	-0.02	-0.05	-0.01	0.06	1			
[12]	Chemical Sciences	0.09	0.11	0.00	-0.19	0.00	0.27	0.19	-0.03	-0.02	0.05	-0.37	1		
[13]	Mathematics & Physics	-0.04	-0.12	-0.06	0.10	0.00	-0.01	-0.08	0.09	-0.05	-0.03	-0.10	-0.18	1	
[14]	Engineering	-0.04	0.10	0.08	0.25	-0.11	-0.59	-0.09	-0.09	0.15	-0.10	-0.29	-0.53	-0.14	1
[15]	Medical Sciences	0.11	-0.13	0.03	-0.13	0.10	0.19	-0.10	0.19	-0.17	0.02	-0.14	-0.26	-0.07	-0.20

Beyond 0.1 the correlation coefficients are significant at standard levels (5%). For variables Mission, Learning and Funding non-standardised values are reported.

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Table 5: Proportion of active researchers who engage in different knowledge transfer activities over the period 2004–2008 (n=133)

	Engagement in KT activities	**Intensity of engagement in KT activities (> 6 times)**
Patents	100	12.78
Informal relational activities	96.99	21.8
Use of non-academic literature	87.22	5.26
Research contracts	66.17	9.8
Participation in initiatives (e.g., corporate events)	65.41	24.06
Joint supervision of PGs	51.88	18.05
Consulting contracts	51.88	1.5
Use of technical infrastructure	45.86	11.28
Joint research projects	45.86	3
Post-doctoral students	44.36	7.52
External teaching	42.11	3.76
Licensing	26.32	2.26
Spin-offs	18.05	1.5

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Table 6: Correlation coefficients of knowledge transfer activities over the period 2004–2008

		[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	[10]	[11]
[1]	Consulting contracts	1										
[2]	Research contracts	0.27	1									
[3]	Joint research projects	0.31	0.24	1								
[4]	Licensing	0.06	0.17	0.07	1							
[5]	Spin-off	0.10	0.17	0.35	0.07	1						
[6]	Post-doctoral students	0.16	0.16	0.33	0.15	0.29	1					
[7]	Use of technical infrastructure	0.16	0.31	0.36	0.14	0.31	0.39	1				
[8]	External teaching	0.39	0.22	0.28	0.18	0.08	0.19	0.35	1			
[9]	Use of non-academic literature	-0.05	-0.13	0.04	-0.03	0.06	0.07	0.13	0.10	1		
[10]	Informal relational activities	0.18	0.15	0.16	0.11	0.08	0.07	0.07	0.15	-0.07	1	
[11]	Participation in initiatives	0.25	0.11	0.19	0.18	0.05	0.11	0.19	0.33	0.20	0.24	1
[12]	Joint supervision of PGs	0.25	0.33	0.34	0.23	0.26	0.38	0.31	0.39	0.13	0.18	0.34

Beyond 0.17 the correlation coefficients are significant at standard levels (5%).

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Table 7: Correlation coefficients of frequent knowledge transfer activities (>6 times over the period 2004–2008)

		[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	[10]	[11]	[12]
[1]	Consulting contracts	1											
[2]	Research contracts	0.38	1										
[3]	Joint research projects	-0.02	0.24	1									
[4]	Licensing	-0.02	0.29	-0.03	1								
[5]	Spin-off	-0.02	0.17	-0.02	-0.02	1							
[6]	Post-doctoral students	-0.04	0.00	0.12	0.15	-0.04	1						
[7]	Use of technical infrastructure	-0.04	0.20	0.22	0.11	0.35	0.17	1					
[8]	External teaching	-0.02	0.20	-0.03	-0.03	-0.02	-0.06	0.18	1				
[9]	Use of non-academic literature	0.25	0.15	-0.04	0.19	-0.03	-0.07	0.02	-0.05	1			
[10]	Informal relational activities	0.08	0.26	0.12	0.17	0.08	-0.01	0.27	0.09	0.28	1		
[11]	Participation in initiatives	-0.07	0.23	0.11	0.03	0.22	-0.03	0.24	0.07	0.10	0.21	1	
[12]	Joint supervision of PGs	-0.06	-0.02	0.15	0.06	0.10	0.16	0.14	0.11	0.15	0.27	0.19	1
[13]	Patent	-0.05	0.25	0.06	0.09	-0.05	0.15	0.01	0.04	-0.09	0.13	0.05	-0.06

Beyond 0.17 the correlation coefficients are significant at standard levels (5%).

Table 8: Motivations for KT: aggregate engagement index, KT breadth and KT depth

	(1)	(2a)	(2b)
	AEI	KT breadth	KT depth
Learning	0.7309	0.0330	0.1446
	[0.548]	[0.031]	[0.105]
Funding	1.2395***	0.0704***	0.3344***
	[0.356]	[0.022]	[0.074]
Mission	1.8476***	0.1208***	0.3132***
	[0.492]	[0.025]	[0.103]
Age	-0.4888	-0.0200	-0.0812
	[0.442]	[0.030]	[0.093]
Research quality	0.0014	0.0034	0.0535
	[0.389]	[0.028]	[0.055]
Research funding	27.6258*	0.7467	3.4857***
	[14.471]	[0.490]	[1.009]
Gender	4.5600***	0.3427***	0.8089**
	[1.158]	[0.104]	[0.363]
Scientific field (Ref: Biological sciences)			
Chemical Sciences	0.3526	0.0805	0.0579
	[1.148]	[0.100]	[0.324]
Mathematics & Physics	3.2092	0.2248	-0.0033
	[3.055]	[0.174]	[0.718]
Engineering	4.8240***	0.2802***	0.8814***
	[1.493]	[0.098]	[0.307]
Medical Sciences	0.9109	0.0485	-0.0241
	[1.442]	[0.141]	[0.422]
Constant	0.5622	1.4444***	-1.3815***
	[1.874]	[0.159]	[0.458]
Log-likelihood	-404.9015	-299.2191	-180.3108
Wald χ^2		187.27[13]	257.22[13]***
F statistic	27.4[13,34]***		
R^2	0.3925		
McFadden's R^2		0.0804	0.1811

Observations	133	133	133

AEI is the Academic Engagement Index calculated following Tartari et al. (2014) and Tartari and Salter (2015). Robust standard errors clustered at the University level and degrees of freedom of the Wald χ^2 and F tests are reported in parentheses. Geographical dummies have been included in the estimates but are not reported for space reasons. * p<0.10, ** p<0.05, *** p<0.01.

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Table 9: Motivations for KT: breadth and depth – robustness checks

	Negative binomial		Zero inflated Poisson		Fractional logit	
	(1a)	(1b)	(2a)	(2b)	(3a)	(3b)
	KT breadth	KT depth	KT breadth	KT depth	KT breadth	KT depth
Learning	0.0330	0.1656	0.0330	0.1132	0.0807	0.2250
	[0.031]	[0.112]	[0.031]	[0.103]	[0.076]	[0.145]
Funding	0.0704***	0.3432***	0.0704***	0.3195***	0.1682***	0.4266***
	[0.022]	[0.081]	[0.022]	[0.102]	[0.055]	[0.095]
Mission	0.1208***	0.3160***	0.1208***	0.2767**	0.2905***	0.4272***
	[0.025]	[0.109]	[0.025]	[0.132]	[0.061]	[0.139]
Age	-0.0200	-0.1078	-0.0200	0.0017	-0.0687	-0.1523
	[0.030]	[0.108]	[0.030]	[0.106]	[0.080]	[0.135]
Research quality	0.0034	0.0606	0.0034	-0.0059	0.0082	0.0587
	[0.028]	[0.063]	[0.028]	[0.076]	[0.067]	[0.080]
Research funding	0.7467	3.5390***	0.7467	3.5045***	2.2904	5.4733***
	[0.490]	[1.090]	[0.490]	[1.174]	[1.767]	[1.960]
Gender	0.3427***	0.8641**	0.3427***	0.5165	0.7564***	1.0615***
	[0.104]	[0.366]	[0.104]	[0.463]	[0.229]	[0.410]
Chemical Sciences	0.0805	-0.0096	0.0805	-0.2266	0.1471	0.0577
	[0.100]	[0.354]	[0.100]	[0.670]	[0.212]	[0.414]
Mathematics & Physics	0.2248	-0.0070	0.2248	0.7215	0.4912	0.0219
	[0.174]	[0.729]	[0.174]	[0.772]	[0.406]	[0.885]
Engineering	0.2802***	0.8554***	0.2802***	0.6847	0.6874***	1.1643***

	[0.098]	[0.311]	[0.098]	[0.685]	[0.212]	[0.397]
Medical Sciences	0.0485	-0.0335	0.0485	-0.1987	0.1306	0.0170
	[0.141]	[0.431]	[0.141]	[0.729]	[0.289]	[0.523]
Constant	1.4444***	-1.4079***	1.4444***	-0.7224	-0.9255***	-3.3457***
	[0.159]	[0.436]	[0.159]	[0.804]	[0.341]	[0.521]
Log-likelihood	-299.2191	-179.0148	-299.2191	-175.9055	-86.0898	-58.5768
Wald χ^2	187.27[13]***	254.04[13]***	187.27[13]***	159.32[13]***	144.66[13]***	249.41[13]***
McFadden's R^2	0.0803	0.1208			0.0524	0.1300
Observations	133	133	133	133	133	133

Robust standard errors clustered at the University level and degrees of freedom of the Wald χ^2 are reported in parentheses. Geographical dummies have been included in the estimates but not reported for space reasons. * p<0.10, ** p<0.05, *** p<0.01

APPENDIX

Comparison of academic inventors and academic non-inventors

As discussed in section 3.1, the sample we run the estimates on is biased towards technology transfer as it only comprises academic inventors, namely faculty who has filed at least a patent in their career. In order to understand whether a bias actually exists and, in case, to gauge its extent, we created a control sample of academic non-inventors (i.e., academic scientists who have never filed a patent during their career) and administered a shorter version of the original questionnaire to them. Similarly to the original sample, the control sample was stratified according to academic position (assistant professor, associate professor and full professor) and scientific field (Life Sciences, Chemistry, Mathematics and Physics, Engineering and Medical Sciences). Only a short version of the questionnaire was administered to the sample comprising academic non- inventors. Notably, three sets of information were retrieved over the period of reference (2004–2008): (i) whether the scientist engaged in KT activities (other than patenting); (ii) the distribution of time devoted to different activities (teaching, basic research, applied research and administrative duties) and (iii) the importance of different motivations to conduct KT activities (which have been aggregated into three main motivations with the procedure described in section 3.3). We also retrieved data on scientific publications by ISI web, which allowed us to build measures of scientific productivity (average number of publications and citations).

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Table A1 Comparison of the samples of academic inventors (original sample) and non-academic inventors (control sample)

	Academic inventors (original sample)	**Academic non-inventors (control sample)**	**Difference tests**	**Sig**
Engagement in KT activities (other than patenting)	83.33%	50.82%	22.4[1]	***
Distribution of activities				
% of time devoted to teaching activities	25%	30.45%	-2.81	***
% of time devoted to basic research	27.4%	24.35%	1.04	
% of time devoted to applied research	27.79%	19.08%	2.98	***
% of time devoted to administrative tasks	17.8%	16.87%	0.45	
Motivations for KT				
Average value of Funding items	2.89	2.87	0.16	
Average value of Learning items	3.19	3.09	0.46	
Average value of Mission items	2.88	3	-1.83	*
Scientific productivity				
Average number of publications	15.25	12.3	0.58	
Average number of citations	219	224.2	-0.06	
Observations	133	61		

The original sample refers to the sample used for the analysis and comprises 133 academic inventors stratified according to academic position (assistant professor, associate professor and full professor) and scientific field (Life Sciences, Chemistry, Mathematics and Physics, Engineering and Medical Sciences). The control sample comprises a sample of 61 non-academic inventors (full list of academics provided by MIUR less the academic inventors contained in CESPRI-PATSTAT) and underwent a similar stratification procedure. Difference tests are all t-tests, apart for the engagement in KT activities where a Pearson χ^2 test is carried out. Degrees of freedom are in square brackets. Significance levels: * <.1, **<.05, ***<.01