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Academics' Motivations and Depth and Breadth of Knowledge Transfer Activities

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ABSTRACT

The debate on the entrepreneurial university has raised questions about what motivates academics to engage with industry as well as what forms these knowledge transfer activities can take. This paper analyses the relationship between different forms of motivations, namely mission (following the entrepreneurial mission of the university), learning (access to wider knowledge base for research enhancement) and funding (obtaining financial resources), and the depth and breadth of knowledge transfer activities, measured by the combination of various formal and informal activities and the frequency of interactions. The study is focused on the case of Italian academics but it covers all disciplines. We find that the learning motivation appears to be less important in Italy while mission and funding prevail, probably due to the peculiarities of the Italian industrial system and to the necessity for Italian academics to look for external funding sources for their research.

Keywords: University-industry relations; joint research; collaborative research; commercialisation; entrepreneurial university; motivation

JEL Classifications: I23; O32

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1. Introduction

A central theme in industrial and technological policy discussions in recent years has been the exploitation of knowledge created at universities to spur the development of old and new sectors and thereby spur economic growth (see, among many other documents, European Commission, 1995, 2007; OECD 2002a, 2002b). Governments at regional, national and international levels consider that the 'entrepreneurial university' has an important role to play in the economic development of their territory via knowledge transfer to the industrial sector (Etzkowitz and Leydesdorff, 2000; Etzkowitz, 2003).

This has stimulated debates among scholars and the literature on this topic of university-industry relationship is now wide (see Perkmann et al., 2013, for a review).

While many studies examine the form knowledge-transfer activities can take, together with their impact on academics' career and scientific productivity, yet relatively few have looked at the motivations of academics to engage with industry.

Also regarding the type of knowledge-transfer activities, while there is consensus on the fact that the forms and type of such activities are numerous (Perkmann et al., 2013), most studies have been concerned with commercialisation activities, often referred to as formal knowledge technology transfer (KTT) activities (patenting, licensing and spinoffs) (Rothaermel at al., 2007). However, other forms of collaborations, such as collaboration and research contracts, student placements in industry, teaching, consulting, and so on) are also important (Landry et al., 2007, 2010; D'Este and Perkmann, 2011). The latter activities are often referred to as informal activities although they are often underpinned by contracts or other formal agreements. Hence the term academic engagement with industry might be preferred (D'Este and Perkmann, 2011; Perkmann et al., 2013).

There is wide evidence of growing academic engagement especially in commercialisation (Perkmann et al., 2013; D'Este and Patel, 2007; Siegel et al., 2007).

There is evidence that technological transfer vary widely across academic institutions, raising the question of what are the factors that differentiate academic researchers in terms of both motivations and opportunities to engage in knowledge transfer activities (regarding academic entrepreneurship: Bercovitz and Feldman, 2008).

Generally the literature finds that academic engagement is determined by individual characteristics (gender, age, seniority, academic success) and organisational and institutional characteristics (size of the department, university policy towards academic engagement). The discipline has a strong influence on the propensity to engage in industry, science and engineering disciplines being more inclined to U-I collaboration, but the discipline also influences the type of academic engagement preferred (Bekkers and Bodas Freitas, 2008).

Main motivations considered in the literature are access to financing, research enhancement as well as the willingness to pursue the university's mission (D'Este and Perkmann, 2011; Lam, 2011). D'Este and Perkmann (2011) in their study of UK engineering and physical scientists consider commercialisation and research-related motivations. Lam (2011) also focuses on the UK and shows that intrinsic motivations are also important in motivating academic scientists, besides financial rewards; importantly he concludes that the different types of motivations interact and should be considered together. This paper is an important reference point for our study, but, while Lam has a limited sample (36 academics from 5 UK major universities), we have a wider sample covering all universities in Italy, where all academics were surveyed. An earlier study (Lee, 2000) found that science and engineering faculty in US research universities engage with industry mainly for reasons of financing and research enhancement.

However, the literature on academics' motivations for KTT activities has a number of shortcomings. First, it has mainly focused on surveys of academics carried out in Anglo-Saxon countries (in UK: D'Este and Patel, 2007; D'Este and Perkmann, 2011; Abreu and Grinevich, 2013; in the USA: Link et al., 2007; in the USA and Canada, analysis of specific knowledge transfer activities: Landry et al., 2007, 2010). One exception is Arvanitis et al. (2008), who study knowledge transfer activities in Swiss universities. While the university system in Anglo-Saxon countries has a longer tradition of links with industry, other countries in the world have stressed the importance of these links and started policies to favour them. Italy is a case in point: it is interesting to study the motivations of academics to engage with industry in Italy because the university culture is much different and some new insights might be found.

Second, the analyses of academic engagement in industry has tended to focus on specific sectors or scientific disciplines, such as science and engineering (D'Este and Perkmann, 2011; Landry et al., 2007, 2010) and life sciences (Gittleman and Kogut, 2003; Murray, 2004). A notable exception is Abreu and Grinevich (2013) who study knowledge transfer activities in the UK in a whole range of academic disciplines. There is indeed considerable variations in the channels and extent of academic engagement across academic disciplines. Abreu and Grinevich (2013) essentially confirm results in the literature that more senior academics are more likely to engage with industry especially in non-commercial activities; female researchers are less likely to realise knowledge transfer, especially informal ones; academics in creative arts, humanities and social sciences are also actively engaged with industry, especially in contract research.

Overall it might be interesting to further explore motivations for academic engagement by distinguishing the types of motivations and the types of KTT activities. This is the aim of this paper.

More precisely in this paper we distinguish between the breadth and depth of academic engagement with industry and we analyse the effects of different types of motivations, namely financing, learning and mission on the breadth and depth of engagement. By financing, learning and mission respectively we mean the motivations linked to access to finance, to enhance knowledge and research, and the willingness to pursue the university's mission.

Based on a survey of Italian academics, we are able to consider an exhaustive set of KTT activities. In addition, given that the questionnaire included questions on the frequency of collaboration with industry, we are also able to build indicators of breadth and depth of collaboration. Indeed, academics generally and simultaneously use different channels of academic engagement, from talks at conferences with industry to research contracts, and they collaborate with different firms at the same time. For instance a researcher might have different consulting contracts with different firms.

Researchers might therefore have different motivations not only to choose particular types of KTT channels, but also to persist in collaboration.

Laursen and Salter (2006) defined the concept of depth and breadth of firms' external search strategies and studied their effects on firms' innovation performance.

We use their concepts and define the breadth of academic engagement by the number of channels or KTT activities used by the researcher, while depth of academic engagement is defined by the extent to which the researcher draws deeply from the different knowledge sources. We hypothesize that different motivations influence the degree of openness of the academics' search process, namely the depth and breadth of his collaboration with industry.

The paper is structured as follows. Section 2 provides literature review and hypotheses, while section 3 presents data and methodology. Section 4 discusses the results, while section 5 concludes.

2. Literature Review and Hypotheses

There are different forms of interactions between academics and industry. Commercialisation of academic innovations has been a primary channel considered in the literature. Commercialisation takes the form of patents, licensing and spinoff, and has a direct impact on industry. Commercialisation has been analysed in the literature using patent data (Azoulay et al., 2009; Bonaccorsi and Thoma, 2007; Hall and Ziedonis, 2001; Henderson et al. 1998; Mowery et al., 2002), citations data (Spencer, 2001), licensing (Thursby and Thursby, 2002, Dechenaux et al., 2011) or spinoff (Shane and Stuart, 2002; Rothermael et al., 2007; Larsen, 2011). Many universities have created facilities dedicated to easing such commercialisation, including science parks, technology transfer offices and incubators. Governments have also helped this form of university-industry interaction by financing facilities and providing grants to industry-university collaborative research projects.

University – industry interactions however also include other channels generally indicated in the literature as informal knowledge transfer channels. These include university-industry contracts, which in turn can take the form of consultancy, academic research or joint research. Informal channels also include networking activities such as participation into conferences, Ph.D or graduate theses done as a project for the firm, students' training periods in firms, etc. All these channels are called informal knowledge transfer, although they are often formalised in specific contracts. For instance, Perkmann and Walsh (2008) analyse the effects of academic consulting on academic research and on firm innovation.

Following the literature (Perkmann et al., 2012; D'Este and Perkmann, 2011) we indicate all these forms of interaction between university scientists and industry as academic engagement with industry.

Link et al. (2007) provide one of the first systemic empirical evidence on the propensity of academics to engage in informal technology transfer. They define formal technology transfer as activity involving a formal instrument such as a patent, a license or royalty agreement. Informal technology transfer is a mechanism facilitating the flow of technological knowledge through informal communication processes, such as technical assistance, consulting and collaborative research. They consider three modes of informal technology transfer: transfer of commercial technology, joint publications with industry scientists and industrial consulting. Based on a survey of US scientists and engineers, they find that male, tenured and research-grant active academics are more likely to engage in all three forms of informal technology transfer. However, they only have dichotomous measures of informal technology transfer and are unable to relate knowledge transfer activities through time. Compared to their study, we have measures of the extent of such activities and a much richer set of data to measure informal knowledge transfer. They also find that star scientists, namely scientists with more publications and more research grants obtained in the past, are more likely to engage in informal knowledge transfer.

Networking and social capital are likely to have positive effects on an academic's propensity to engage in knowledge transfer. The evidence on the effect of social capital on entrepreneurship is wide (Labory and Simoni, 2007); in the case of academic entrepreneurship, Murray (2004) shows that both the human capital and the social capital of academics in biotechnology influenced the success of their relationships with firms.

The literature has also stressed that there might be complementarities between the different knowledge transfer activities. Complementarities arise when "doing more of one thing increases the returns to doing more of another" (Milgrom and Roberts, 1995, p. 181). Complementarities have been found between publishing and patenting (Azoulay et al., 2009; Fabrizio and Di Minin, 2008), teaching, research and consulting (Mitchell and Rebne, 1995), commercial and non-commercial activities (Siegel et al., 2003; Link et al., 2007). Landry et al. (2010) analyse complementarities between the whole range of knowledge transfer activities, namely publishing, teaching, informal knowledge transfer, patenting, spinoff creation and consulting. Using a survey a Canadian scientists and engineers, they find that the six knowledge transfer activities are interdependent and reinforce each other, except for publishing and teaching which appear substitute. Many researchers find a complementarity between publishing and patenting (Fabrizio and Di Minin, 2008, Azoulay et al., 2009). For this reason, and because Italian academics do not patent much (legislation of 2001 on this). in the following empirical analysis we use publications rather than patenting as a control for past research productivity of academics,.

Landry et al. (2007) consider not only commercialisation but also other forms of academic engagement, of knowledge transfer activities; they classify the determinants of knowledge transfer into attributes of knowledge (publications, research fields, research projects that focus on users' needs, novelty of research findings), financial assets (private, government or internal funding), organisational assets (university size, research unit size, teaching requirements), relational assets (linkages with potential non-academic users), personal assets (experience) and control variables such as gender and seniority. Knowledge transfer activities are classified into commercial and non-commercial; the former include patenting, engaging in spin-off creation and consulting services; the latter include publications, teaching and informal knowledge transfer; consulting services are defined as activities commissioned by industrial clients or government agencies including contract research and consulting activities. The determinants of knowledge transfer activities are examined by assuming that academics control bundles of idiosyncratic resources and capabilities which are deployed and mobilised in the accomplishment of their knowledge transfer activities and include financial, knowledge, organisational, network and personal assets.

Regarding academic motivations to do knowledge transfer, the literature has looked at the motivations to do commercialisation only or to do knowledge transfer activities more generally.

Interestingly, the literature on academics' motivations to engage in knowledge transfer activities is essentially empirical, with conceptual discussions of motivations then checked empirically rather than discussions of theoretical models to be checked. One exception is Link et al. (2007) who mention the principal-agent model of Jensen et al. (2003) of the process of university disclosure and university licensing through technological transfer offices.

The results of such conceptual and empirical literature let to conclude that a resource-based theory of the firm is not appropriate to study academics' knowledge transfer activities, since academics are motivated by other objectives than maximising profits and market shares as firms do. This view is likely to exclude some important motivations of academics.

As stressed by Bruneel et al. (2010), academics accept lower wages to work at universities rather than private firms or research centres and therefore are likely to be motivated by intrinsic goals and the social objectives of the university (see also Stern, 2004). According to Dasgupta and David (1994) university scientific research explicitly rejects monopolization of new ideas and secrecy and favours knowledge disclosure, which stands in contrast to profit-maximising businesses. Indeed, in their view academics' motivations are determined by different factors. A primary motivation is recognition in the academic community, which is a requirement for promotion and tenure. Recognition in the academic community depends on publications, especially on scientific journals with impact factor, presentations at conferences and workshops, grants and research funds from public or private organisations. Financial gains, obtained by knowledge transfer activity, is useful less for personal benefits then to secure acquisition of human and physical capital for their research, which may increase their reputation.

Bruneel et al. (2010) highlight that the university system is rooted in Mertonian norms of science that include communalism, universalism, disinterestedness and organised scepticism; the knowledge transfer activities are not in conflict with this view, as the creation of new and high quality knowledge that can be diffused to the economy and the society and contribute to the cultural, civil and economic development of the territory is to a certain extent the most important mission of the university, which academics are aware of and which determines their motivation and choices in performing their job. While Stephan (1996) suggests that scientists might be interested in earning money, Lam (2011) finds that financial rewards play a small role in motivating academics to commercialise knowledge; he classifies motivations for commercialisation in three categories: 'gold', meaning financial rewards, 'ribbon', meaning reputational and career rewards and 'puzzle' meaning intrinsic satisfaction.. According to Bammer (2008), academics participate in research collaboration for different reasons, including access to complementary expertise, access to additional equipment and resources, acquisition of prestige, visibility and recognition

Hypotheses

Given the above discussion, the following hypotheses are tested in this paper.

First, we derive hypothesis regarding the determinants of academic engagement already discussed in the literature, considering general engagement and not distinguishing its breadth and depth.

H1. Gender positively determines both depth and breadth

Like being a male researcher increases the probability of engaging with industry, we expect both depth and breadth to be positively influenced by this variable.

H2. Age negatively influences the breadth of KTT activities, but not necessarily the depth.

Young researchers in earlier stages of their career are likely to explore different types of engagement with industry, both because they need to build a reputation in the academic and industry networks and because they are building their networks, hence trying different activities.

Elder researchers might prefer focusing on a few KTT activities, with the partners they've built trust with and also because they might have less time to dedicate to these activities.

H3. Previous experience in obtaining public funding positively determines both depth and breadth.

The literature finds that previous experience in obtaining funds and grants positively affect the propensity to engage with industry. For the same reason obtaining public funds in the past should positively influence both depth and breadth.

H4. The quality of the academics' research positively affect the depth of engagement with industry, not the breadth.

This is because high quality scientists might focus on a few collaborations at a deep level, providing firms with the new knowledge they need to develop new products and technologies. Industry might also prefer the collaboration with the star scientist to be rather exclusive, so as to draw patents from the research done in collaboration.

H5. Being located in the North of Italy positively influences both depth and breadth of academic engagement.

This is because industries are more dynamic in the North of Italy, so that academics located in this region have more opportunities for knowledge transfer, both in terms of channels and in terms of frequency of collaboration with industry.

Regarding the interaction between academic motivations and breadth and depth, we expect the following:

H6. Mission positively determines both depth and breadth, but more breadth.

This is because an academic motivated by the university mission is likely to use different channels for knowledge transfer, namely research collaboration, consulting but also teaching and student placements.

Since a deeper collaboration allows to build trust in the relationship and exchange and create more knowledge, mission should also positively affect depth.

H7. Funding positively affects both breadth and depth, but more breadth.

This is because multiplying channels allows to have more sources of funds (breadth) but also depth allows to consolidate relationships with industry through time and may allow to get more consistent contracts.

H8. Learning positively affects depth but not breadth.
This is because research enhancement and access to wider knowledge base requires deeper relationships using a limited number of channels.

However, the different motivations might also interact. We expect in particular mission and learning to interact in determining breadth and depth, because the belief in the university mission regarding knowledge transfer to industry should be linked to the objective of research enhancement, since higher interactions with industry allows to transfer knowledge and to better adapt teaching to the requirements of industry. Hence the last hypothesis (H9).

H9. Mission and learning strongly interact to determine both depth and breadth.

3. Data and methodology

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. The project contained a survey intended to collect information on the Knowledge and Technology Transfer (henceforth KTT) interactions of Italian scientists with industry by administering a structured questionnaire to a representative sample of academic researchers. The questions concerned information on individual characteristics, motivations and obstacles to carry out KTT activities and a full set of detailed mechanisms through which the scientists interact with external agents.
The data refer to the 2004–2008 period. The design of the survey and the construction of the database underwent a careful preparation phase.
At the beginning of 2009, in-depth face-to-face interviews were conducted with the directors of three Knowledge and 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 for 45–60 minutes and were conducted by two people, with one researcher posing the questions and the other taking notes. The main purpose of these interviews has been to: (i) collect preliminary information on KTT activities in the Italian Higher Education System; (ii) build a classification of the different channels of KTT though which Italian academics interact with

industry and (iii) provide a distinction between formal and informal channels for KTT. The results of this preliminary analysis were used to design the questionnaire.

The research group intended to administer the questionnaire to a representative sample of academic inventors working in Italian Public Universities in a selected number of fields of science (Life Sciences, Chemistry, Mathematics and Physics, Technological Sciences and Medical Sciences).[1] For this purpose, on September 2008 a list containing the national population of academic scientists was downloaded from the institutional website of the Italian ministry of university and research (MIUR) and subsequently matched to a database containing information on the full list of Italian academic inventors, namely CESPRI-PATSTAT.[2] The resulting population included 31332 academic scientists.

Next, a subset of 380 target academics was extracted. This subset was stratified according to the official categorization of the field of science provided by the Italian Ministry of University and Education3 (Life Sciences, Chemistry, Mathematics and Physics, Technological Sciences and Medical Sciences) and academic position (assistant professor, associate professor and full professor). Between March and June 2009, the academics were contacted and asked to fill the online questionnaire described earlier, and 189 did so (response rate: 49.74%). 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.

Table 1 provides the distribution of academics contained in our sample for a full set of different typologies of interaction with industry for different fields of science. Interestingly, Table 1 shows that contractual-based and informal means of knowledge and technology transfer (e.g. use of non-academic literature, research contracts, secondments to industry, etc.) are a frequent KTT activity among university academics analyzed in this paper. Indeed, as Table 1 shows, these arrangements are more frequently used than more formal (and widely studied) KTT channels, such as licenses and spin-offs. It is also interesting to note that there are significant differences by scientific discipline: scientists in engineering-related fields have a much higher propensity to engage in the full set of activities – e.g. above 70% of scientists in Engineering engage in academic consulting or contract research over the five-year period

1 The choice to rely on Italian academic inventors, defined broadly as those researchers affiliated to Italian universities that appear as inventors in at least one patent filed at the European Patent Office, comes from the necessity to balance to contrasting features. On the one hand, we wanted to have a sample as much representative as possible of the overall population of Italian academics. On the other hand, we wished to maximize the changes of surveying academics with an active portfolio of knowledge and technology transfer activities.

2 As 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 This classification closely resembles the UNESCO international standard nomenclature for fields of science and technology (UNESCO, 1974).

analyzed, compared to less than 60% for the cases of scientists who belong to the others scientific disciplines analyzed.

Table 2 provides the correlation matrix of the different channels through which academic scientists in our sample interact with industry. Quite interestingly, the correlation among different channels is reasonably low meaning that the extent of overlap among different typologies of involvement with industry is negligible.

[Insert Table 1 and 2 about here]

Econometric model

Dependent Variable and Methods

As discussed in the Introduction, we are interested in examining the relationship between the motivations to carry out KTT activity and the different forms through which this interaction can be realized (KTT breadth) as well as the intensity with which KTT activity is carried out (KTT depth).

To collect data for the construction of our dependent variables, we use information coming from a set of questions contained in our questionnaire and focusing on a large set of KTT mechanisms. The respondents to our questionnaire were asked to rate the frequency of interaction with industry through a number of different mechanisms during the period 2004-2008.[4] The two main dependent variables are then created following Laursen and Salter (2006) in their construction of knowledge breadth and depth variables.

On the one side, KTT breadth is constructed as a combination of the 13 mechanisms listed in footnote 7. As a starting point, each of the 13 mechanisms are coded as a binary variable, 0 being no use and 1 being use of the given mechanism. Subsequently, the 13 mechanisms are simply added up so that each scientist gets a 0 when no mechanisms are used, while the scientist gets the value of 13, when all mechanisms are used. Although our variable is a relatively simple construct, it has a reasonable degree of internal consistency (Cronbach's alpha coefficient = 0.73).

On the other side, KTT depth is defined as the extent to which scientists draw intensively from different mechanisms for knowledge and technology transfer activity. Accordingly, this is constructed using the same 13 mechanisms as those used in constructing KTT breadth. In this case each of the 13 mechanisms are coded with 1 when the scientist in question reports

4 The different means of interactions were: consulting contracts, research contracts; joint research projects; patent licenses; patents co-invented with industry; participation in the creation of spin-offs; supervision of post-doctoral students carrying out research activity in private companies; use of technical infrastructure from industry; teaching activity carried out in companies; use of non-academic literature in own research; co-supervision of post-graduate theses with industry and other more informal activities of knowledge transfer (such as phone calls made with industry practitioners to solve specific research problems, etc.).

that he/she uses the mechanism to a high degree (i.e. 3 or more times in the period 2004-2008) and in the case of no, low (1 time), or medium (2 times) use of the given mechanism. As in the former case, the 13 mechanisms are subsequently added up, so that each scientist gets a score of 0 when no mechanisms are frequently used, while the scientist gets the value of 13 when all KTT mechanisms are used to a high degree (Cronbach's alpha coefficient = 0.6).

The two dependent variables are of a count type. Accordingly, we implement count models to take this into consideration. The two models that are estimated can be written as:

$$KTTBreadth_i = \alpha_1 + \beta_1 Mission_i + \beta_2 Learning_i + \beta_3 Funding_i + \delta_1^T Z_i + \varepsilon_{1,i}$$

$$KTTDepth_i = \alpha_2 + \beta_4 Mission_i + \beta_5 Learning_i + \beta_6 Funding_i + \delta_2^T Z_i + \varepsilon_{2,i}$$

where $KTTBreadth_i$ and $KTTDepth_i$ 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 if a Poisson specification estimated via quasi-maximum likelihood as, contrary to negative binomial models, 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). Further robustness checks have been implemented and refer to two separate issues. First, we controlled whether the estimated coefficients are biased due to a problem of overdispersion (conditional expected value of KTT breadth and depth are relatively far away from its conditional variance). To control for that, we run negative binomial regression. Second, to account for the relative high number of zeros characterizing KTT depth, we estimate a zero inflated Poisson model (Cameron & Trivedi, 1998).[5]

Independent and control variables

Our three main independent variables refer to academics' motivations for engaging with industry: (i) acquisition of new knowledge for future research (*Learning*); (ii) broadening of University mission (*Mission*) and (iii) funding new research activity (*Funding*). The three variables were built from responses to the following question contained in the survey: "Please rank the following motivations to engage with industry according to their level of importance". 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 contained in this question in order to synthesize the information in

5 All different specifications provide similar results to the ones presented below. They are available from the authors upon request.

underlying common factors driving decisions to carry out KTT activities.[6] The three resulting predicted factors are used as main explanatory variables in the econometric model outlined above. Results of the factor analysis are presented in Table 3. Note that different methods of factor extraction – principal components, iterated principal factors and maximum likelihood – yield consistent results. Previous literature assists the interpretation of these three constructs (D'Este & Perkmann, 2011; Lam, 2011). The first factor includes items that involve learning opportunities in the engagement with industry. Accordingly, this is labeled *Learning*. The second group, *Mission*, contains a range of items that relate to the overall perceived usefulness of research for society at large. It is worth stressing how this motivation has not been detected in previous empirical works and it therefore constitutes a novel contribution to the extant literature in itself. The third groups relates to funding possibilities coming from the interaction with industry. The corresponding group is labeled *Funding*.

The other explanatory variables, which act mainly as controls, are *Age* which controls for age effects on the frequency of engagement with industry; *Gender* is a dummy variable taking value 1 whether scientist *i* is a male and 0 if she is a woman. We also control for the amount of research funding the academic scientist is able to attract, as previous literature showed that this can be an important determinant of the intensity of engagement with industry at the scientist level (Gulbrandsen & Smeby, 2005; Landry et al., 2010). *Public Funding* is equal to the share of public funding for research obtained over the total amount of funding the same scientific field during the 2004-2008 period.[7] Variable *Research Quality* controls for the quality of scientific production of scientist *i*, as more productive scientists are more attractive for firms willing to collaborate with industry and, thus, are more likely to present a higher degree of interaction with industry. To build the variable, we make use of the Journal Citation Reports, published yearly by the Institute for Scientific Information. 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 the published output in the period 2004-2008 and divide by the publication count in the

6 The 16 items relating to motivation for the involvement in interactions with industry 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 competences; 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 own area of research; 9)gaining experience on practical problems; 10) opportunity to test own research findings in practice; 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; 16) improving the reputation of science.

7 Public research funding refers to the funding obtained under the public Italian competitive program "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 sources of funding for public research.

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).

To capture the role played by star scientists in the KTT process we use a dummy (*Star*) that equals 1 in case the scientist is in the top quartile (i.e. top 25%) of the distribution of *Research Quality*.

We control also for environment, status and field in which the scientist operates. In particular: we control for geographical location of the University the scientist is affiliated with (*Geographical*);[8] To control for a status effect, we include a number of dummy variables relating to the academic position of the scientists contained in our sample (*Status*); finally, we control for the specific effects of the scientific field using a series of field-specific dummies (*Scientific Fields*).[9] We also include a complete set of cohort dummies (*Cohort*) to control for effects stemming from different individuals that were born in different periods in time.

We also included in the analysis the quadratic terms of *Learning*, *Mission* and *Funding*, in order to test if their effect on KTT breadth and depth is linear or not and the interaction among the three motivations, in order to verify if there are some substitution effects among the motivations or, on the contrary, they are reciprocally reinforcing.

Finally, in line with the arguments put forward in the theoretical section, we included some interaction effects in order to test the moderating effect of scientific productivity and academic position on the relationship between motivations and KTT breadth and depth.

In Table 4 we provide descriptive statistics of the variables used in this study while Table 5 reports the correlation matrix for the covariates. In general, the correlation across the independent variables is low, thus suggesting the absence of any relevant problems of multicollinearity.

[Insert Table 3, 4 and 5 about here]

4. Results

We estimated five different regression models; results are reported in Tables from 6 to 9.

All the models are estimated twice, having both *KTTBreadth* and *KTTDepth* as dependent variable. The first model is the basic one, including the academic motivations and all the control variables; the second model adds to such variables the quadratic terms of academic

8 Geographical areas refer to the following categories: (i) North; (ii) Center and (iii) South and islands.
9 Following the classification provided by the Italian Ministry of University and Research, we considered the following scientific fields: Life Sciences, Chemistry, Mathematics and Physics, Technological Sciences and Medical Sciences.

motivations; the results of the estimation of these models are presented in Table 6[10]. The third model adds to the baseline model the interactions between the three motivations among them (the product of each motivation for one of the two others and the product of the three motivations) but excludes the control dummy variables for status, geographic, scientific fields and cohort; the results are presented in Table 7. The fourth model adds to the baseline model the quadratic terms of academic motivations and the interactions between the academic motivations and the variable indicating the scientific productivity (*Star*), excluding the control dummy variables; the results are presented in Table 8. The fifth model adds to the baseline model the quadratic terms of academic motivations and the interactions between the academic motivations and the variables indicating the academic position (*Full Professor* and *Academic Professor*), excluding all the control variables[11]; the results are shown in Table 9.

We report now the significant results of our estimations, where we consider significant the coefficients above the 90% level.

All the academic motivations always have a positive sign, but *Mission* is significant in all but one (model 4.2 for *KTTDepth*) of the estimated models, *Funding* is significant in many cases (Models 1 and 2 both for *KTTBreadth* and *KTTDepth*; model 3 for *KTTBreadth*; model 4.2 for *KTTBreadth* and all models 4 for *KTTDepth*; model 5.2 and 5.3 for *KTTDepth*) and *Learning* is significant only in a few cases (Models 1, 2, 4.1, 4.2 and 5.3, always for *KTTDepth* only).

Let us consider now the quadratic term of academic motivations and their interaction terms. The quadratic term of *Mission* is always negative; it is significant for *KTTBreadth* in almost all models, (it is not significant for models 4.2 and 4.3) and never significant for *KTTDepth*; this indicates a decreasing effect of the *Mission* motivation on the variety of forms of KTT activities. The quadratic term of *Funding* is always negative and significant in all models but one (model 4.3 for *KTTDepth*), indicating a decreasing effect of the *Funding* motivation on the variety of forms of KTT activities and on the intensity of involvement in KTT activities. The quadratic term of *Learning* is always positive but never significant.

Model 3 includes the interaction among the motivation variables: only the interaction between *Mission* and F*unding* has a significant coefficient for *KTTDepth*; as the sign is positive, we may conclude that the greater is the *Funding* motivation, the larger is the effect of the *Mission*

10 In the tables the models are identified with a number (1 for model 1, 2 for model 2, etc.) and a letter: *a* when *KTT Breadth* is the dependent variable, *b* when *KTT Depth* is the dependent variable.

11 The interactions between the academic motivations and the variable *Star* are not included together in the same estimation, but three different regressions are estimated, each of them including the interaction between one motivation with *Star*. Therefore we may say that the fourth model is, more precisely, a group of three models (in the tables we identify them as 4.1, 4.2 and 4.3). The same holds for the interactions between academic motivations and the variables indicating the academic status: even in this case we may say that the fifth model is more precisely a group of models (in the tables we identify them as 5.1, 5.2 and 5.3).

motivation on the intensity of involvement in KTT activities (and *vice versa:* when *Mission* motivation is stronger, the effect of *Funding* motivation on *KTTDepth* is larger).

Among the control variables, *Gender* has a positive and significant effect on *KTTBreadth* and on *KTTDepth* (only in Model 3 for *KTTDepth* the coefficient is not significant), meaning that males are involved in more intense and diversified KTT activities. The variety of KTT activities decreases with the age (younger professors are involved in more diversified KTT activities), as the negative and significant effect of *Age* on *KTTBreadth* in all the models implies, while the effect on *KTTDepth* is never significant. *Cohort 1961-1970* results to have less *KTTBreadth* if compared with cohort 1930-1940.

As regards geographic localization, the dummy variable for Centre has a positive and significant effect on *KTTBreadth* , meaning that teachers in the Centre of Italy are *ceteris paribus* involved in more varied KTT activities than teachers located in the South and Islands. The dummy variable for North has also a positive sign, but it is not significant. Both variables for Centre and North are positive also for *KTTDepth*, but not significantly.

Among scientific sectors, engineering shows an higher breadth and depth of KKT activities if compared with biological sciences, while the other sectors do not significantly differ from the benchmark category.

Public Funding has a positive and significant effect both on *KTTBreadth* and *KTTDepth (*only in model 5 for *KTT Depth* the coefficient is not significant), meaning that those professors who obtain an higher percentage of public funds are also more involved in KTT activities.

Research Quality and the academic status have no significant direct effect on *KTTBreadth* and *KTTDepth.* Nevertheless, these variables have some significant effect on *KTTBreadth* and *KTTDepth* if we consider their interaction with the academic motivation for technology transfer. In fact the interaction between *Funding* and *Star* is negative and significant for *KTTDepth*; this result means that the effect of *Funding* motivation on the intensity of involvement with industry is weaker for star-scientists. The interactions between *Mission* and the dummy variables for academic status (*Full Professor* and *Associate Professor*) are negative and significant both for *KTTBreadth* and *KTTDepth*); these results mean that the effect of *Mission* motivation on the intensity and variety of involvement with industry is weaker for professors at the top of the academic career than at its beginning; the interaction between *Learning* and the variables for academic status are negative and significant for *KTTDepth*, meaning that the effect of *Mission* motivation on the intensity of technology transfer activity is greater for professors at the beginning at their career.

Synthesis of results

Expanding the mission of the university unequivocally appears as a motivation to increase, in terms of variety and intensity, the involvement in KTT activities. The possibility to raise funds is another important motivation, as it results from many of our estimations; the effect of this motivations is not linear, as it pushes the involvement in KTT activities at a decreasing rate. The possibility to expand their own knowledge has, on the contrary, a statistically uncertain (even though always positive in our sample) effect on the professors involvement in KTT activities. These motivations are not alternative, on the contrary they are reciprocally reinforcing: this result is statistically significant for mission and funding motivations.. The analysis lets to sketch a portrait of the scientist more involved in KTT activities: he is an engineer, male, young and able to obtain many public funds with research projects; *ceteris paribus*, scientists in central regions of Italy are more involved in more diversified KTT activities. There is no significant relationship between the academic level and the quality of publications on one side and the involvement in KTT activities on the other side, but for professors at the beginning of their career the importance of mission and learning motivation (their effect on involvement in KTT activities) is larger than for their colleagues with an higher academic status; besides, for better (in terms of publications quality) scientists the importance of funding motivation is smaller than for their colleagues.

Regarding the hypotheses formulated in Section 2, our results are as follows.

H1. Gender indeed positively determines both depth and breadth.
Like being a male researcher increases the probability of engaging with industry, we expect both depth and breadth to be positively influenced by this variable.

H2. Age negatively influences the breadth of KTT activities, but not necessarily the depth.
Young researchers in earlier stages of their career are indeed more likely to explore different types of engagement with industry, leaving deepening of collaboration to later stages of their careers.

H3. Previous experience in obtaining public funding positively determines both depth and breadth.

H4. The quality of the academics' research positively affect the depth of engagement with industry, not the breadth.
In effect results show that the higher the academic's quality, the lower the breadth but the higher the depth: the scientist appears to focus knowledge transfer on a few activities, which are pursued intensively though, such as a big collaboration research contract with a firm.

H5. Being located in the North of Italy positively influences both depth and breadth of academic engagement.
Contrary to our expectations we find that being located in the South of Italy positively affects both depth and breadth of KTT activities. This might be due to the fact that being located in a wealthier region makes it easier to obtain public funds and researchers look less towards industry. In fact the correlation matrix (Table 5) shows that public funding is more correlated with location in the North than in the South, and that the motivation "funding" seems to prevail over the other two motives (learning and mission).

H6. Mission positively determines both depth and breadth, but more breadth.
This result is as expected, mission determines both breadth and depth.

H7. Funding positively affects both breadth and depth, but more breadth.

H8. Learning positively affects depth but not breadth.
Contrary to expectations learning does not appear to be a significant determinant of neither breadth nor depth, at least on its own.

H9. Mission and learning strongly interact to determine both depth and breadth.
In line with results on H8, we find that the motivations mission and funding mostly interact to determine breadth and depth.

5. Conclusion

Our results suggest that academics' engagement with industry takes multiple forms and is primarily driven by the willingness of academics to make their knowledge base available to industry (mission) as well as to obtain external funding.

This might be interpreted as a result of Italy's industrial base, which is specialised in low tech sectors and lack development in high tech sectors. University scientists therefore feel they can have a role to play to promote industrial development by transferring their knowledge to industry. In addition, the problem of research funding appears to be highly felt, since the funding motivation is one of the most significant in determining both depth and breadth of KTT activities.

Like special issue of Research Policy 2011, our findings suggest the inadvisability of internal academic policies that set similar levels of academic engagement for all academic researchers (Guldbransen et al., 2011).

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Table 1. Proportion of active researchers who engage in different knowledge and technology transfer activities over the period 2004-2008, by field of science (%):

	Life Sciences n=22	Chemistry n=54	Mathematics and Physics n=6	Technological Sciences n=39	Medical Sciences n=12
Joint supervision of PGs	36.36	48.15	33.33	74.36	33.33
Secondments to industry	54.55	64.81	66.67	71.79	66.67
Informal activities	95.45	96.30	100.00	100.00	91.67
Use of non-academic literature	81.82	96.30	83.33	79.49	83.33
External teaching	31.82	38.89	50.00	58.97	16.67
Use of Technical Infrastructure	40.91	35.19	33.33	71.79	25.00
Post-doctoral students	31.82	42.59	33.33	61.54	25.00
Spin-offs	31.82	7.41	16.67	28.21	8.33
Patents	100	100	100	100	100
Licensing	13.64	38.89	16.67	20.51	16.67
Joint research projects	31.82	38.89	50.00	66.67	33.33
Research contracts	40.91	61.11	83.33	87.18	58.33
Consulting contracts	31.82	38.89	83.33	76.92	50.00

Table 2: Correlation coefficients for different knowledge and technology 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 activities	0.18	0.15	0.16	0.11	0.08	0.07	0.07	0.15	-0.07	1	
11	Secondments to industry	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%).

Table 3: Factor Analysis

		Iterated Principal Factors			Maximum Likelihood			Principal Components		
		Factor 1	*Factor 2*	*Factor 3*	*Factor 1*	*Factor 2*	*Factor 3*	*Factor 1*	*Factor 2*	*Factor 3*
Learning	Access to complementary competences	**0.6539**	0.0027	0.1313	**0.6488**	0.0006	0.1474	**0.6206**	0.02	0.1266
	Strong predisposition to research	**0.4219**	0.2256	0.0118	**0.4086**	0.2253	0.0583	**0.4466**	0.237	-0.0289
	Exchange of ideas and experiences	**0.5257**	0.1167	0.1014	**0.5389**	0.1226	0.1017	**0.5451**	0.0942	0.1159
	On-site experience for staff and/or students	**0.7045**	0.2179	0.0738	**0.6961**	0.2151	0.091	**0.6881**	0.2129	0.0902
	Additional research insights	**0.5732**	0.1997	0.0799	**0.5794**	0.2057	0.0536	**0.5674**	0.1909	0.1007
	Experience on practical problems	**0.4358**	0.4035	0.0179	**0.4276**	0.4043	0.031	**0.4432**	0.3868	0.0447
	Testing own research findings in practice	**0.4014**	0.3676	0.0888	**0.401**	0.3637	0.0605	**0.4089**	0.3683	0.0961
	Job prospects for students/staff	**0.4959**	0.2822	0.151	**0.5082**	0.2937	0.0787	**0.4927**	0.2599	0.1972
Mission	Extending university mission	0.1625	**0.5394**	0.2188	0.1701	**0.5482**	0.1815	0.1627	**0.5106**	0.2673
	Diffusion of a particular technology	0.2021	**0.4963**	0.0859	0.2224	**0.4751**	0.0611	0.1843	**0.5486**	0.0775
	Diffusing key research findings	0.2435	**0.5411**	0.144	0.2403	**0.5177**	0.1764	0.2369	**0.5784**	0.1244
	Promoting local development	0.1487	**0.5285**	0.1101	0.1493	**0.5646**	0.071	0.1441	**0.5179**	0.1764
	Improving the reputation of science	0.0946	**0.6956**	0.1281	0.0803	**0.7009**	0.1635	0.1173	**0.646**	0.1529
Funding	Funding of public research	0.1059	0.2073	**0.2813**	0.1233	0.199	**0.2545**	0.0931	0.1918	**0.3386**
	Additional resources for basic research	-0.0016	0.0975	**0.8331**	-0.0153	0.0776	**0.9969**	0.0205	0.105	**0.6572**
	Further resources for the research team	0.2081	0.1849	**0.6134**	0.2136	0.208	**0.519**	0.2014	0.1566	**0.6291**
	Cumulative % of variance explained	0.4352	0.5635	0.6657	0.2078	0.3813	0.5272	0.2967	0.3988	0.482

Rotation method: Varimax with Kaiser normalization
Note: loading in bold indicate to which factor the item was assigned

Table 4: Descriptive Statistics (n=133)

Variable	Mean	Median	Std.Dev.	Min	Max
Dependent Variables					
KTT Breadth	7.421	8	2.783	2	13
KTT Depth	1.098	1	1.397	0	6
Independent Variables					
Learning	0	-0.120	1.180	-3.094	2.738
Mission	0	0.114	1.153	-3.880	2.434
Funding	0	0.162	1.021	-2.283	1.544
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
Assistant Prof.	0.060	0	0.239	0	1
Associate Prof.	0.308	0	0.464	0	1
Full Prof.	0.632	1	0.484	0	1
South	0.180	0	0.386	0	1
North	0.602	1	0.491	0	1
Center	0.218	0	0.414	0	1
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
1941-1950 Cohort	0.361	0	0.482	0	1
1951-1960 Cohort	0.353	0	0.480	0	1
1961-1970 Cohort	0.143	0	0.351	0	1

Table 5: Correlation Matrix

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	Learning																				
2	Mission	-0.15																			
3	Funding	-0.03	0.02																		
4	Gender	-0.02	-0.07	-0.15																	
5	Age	0.07	-0.11	0.00	0.36																
6	Research Quality	-0.02	-0.03	0.15	-0.27	-0.05															
7	Public Funding	0.12	0.03	0.01	0.08	0.21	0.01														
8	Assistant Prof.	0.13	-0.02	-0.14	-0.22	-0.29	-0.07	-0.09													
9	Associate Prof.	-0.14	0.08	0.07	-0.30	-0.37	0.16	-0.15	-0.17												
10	Full Prof.	0.07	-0.07	0.01	0.39	0.49	-0.12	0.18	-0.33	-0.87											
11	South	0.02	0.07	0.21	-0.04	-0.08	0.09	-0.09	-0.12	-0.02	0.07										
12	North	-0.13	0.03	-0.23	0.16	0.00	-0.16	-0.12	0.21	0.01	-0.11	-0.58									
13	Center	0.14	-0.10	0.08	-0.14	0.08	0.10	0.23	-0.13	0.00	0.06	-0.25	-0.65								
14	Biological Sciences	-0.08	-0.04	-0.05	-0.01	0.06	0.23	-0.02	-0.03	0.05	-0.04	-0.05	-0.01	0.06							
15	Chemical Sciences	-0.03	0.05	0.14	-0.19	0.00	0.27	0.19	-0.08	0.14	-0.10	-0.03	-0.02	0.05	-0.37						
16	Mathematics & Physics	0.02	-0.15	-0.05	0.10	0.00	-0.01	-0.08	-0.06	0.01	0.02	0.09	-0.05	-0.03	-0.10	-0.18					
17	Engineering	0.08	0.12	-0.17	0.25	-0.11	-0.59	-0.09	0.11	-0.18	0.12	-0.09	0.15	-0.10	-0.29	-0.53	-0.14				
18	Medical Sciences	0.02	-0.11	0.14	-0.13	0.10	0.19	-0.10	0.03	-0.04	0.02	0.19	-0.17	0.02	-0.14	-0.26	-0.07	-0.20			
19	1941-1950 Cohort	0.12	-0.06	0.07	0.22	0.41	-0.12	0.06	-0.12	-0.26	0.31	0.01	0.00	-0.02	0.00	-0.08	-0.01	0.07	0.04		
20	1951-1960 Cohort	-0.13	0.05	-0.07	-0.20	-0.41	0.13	-0.17	0.01	0.15	-0.15	0.10	-0.11	0.03	-0.03	0.03	0.14	-0.10	0.04	-0.56	
21	1961-1970 Cohort	-0.06	0.09	0.01	-0.21	-0.62	-0.05	-0.04	0.26	0.29	-0.40	-0.02	0.11	-0.11	-0.01	-0.03	-0.09	0.16	-0.13	-0.31	-0.30

Beyond 0.1 the correlation coefficients are significant at standard levels (5%).

Table 6: Determinants of Knowledge and Technology Transfer (KTT) breadth and depth: baseline results (Models 1 and 2)

	KTT Breadth (1a)	KTT Depth (1b)	KTT Breadth (2a)	KTT Depth (2b)
Learning	0.0282	0.1796*	0.0256	0.1605*
	[0.024]	[0.093]	[0.024]	[0.094]
Mission	0.1039***	0.2868***	0.0934***	0.2908***
	[0.025]	[0.102]	[0.025]	[0.112]
Funding	0.0671**	0.2927***	0.0526*	0.2607**
	[0.029]	[0.109]	[0.032]	[0.125]
$Learning^2$			0.0134	0.0357
			[0.012]	[0.051]
$Mission^2$			-0.0211*	-0.0729
			[0.013]	[0.068]
$Funding^2$			-0.0550**	-0.2773*
			[0.027]	[0.159]
Gender	0.2918***	0.6522*	0.3077***	0.6604*
	[0.101]	[0.344]	[0.103]	[0.364]
Age	-0.0213**	-0.0144	-0.0251***	-0.0366
	[0.009]	[0.034]	[0.010]	[0.035]
Research Quality	0	0.0542	-0.0043	0.0371
	[0.023]	[0.078]	[0.025]	[0.099]
Public Funding	0.7638**	2.6633**	0.6441*	2.0984*
	[0.360]	[1.317]	[0.340]	[1.237]
Status dummies (Ref. Cat.: Assistant Prof.)				
Associate Prof.	-0.0071	0.0602	-0.0378	-0.0834
	[0.151]	[0.482]	[0.161]	[0.488]
Full Prof.	0.1127	0.429	0.076	0.2344
	[0.160]	[0.526]	[0.173]	[0.548]
Geographical dummies (Ref. Cat.: South & Islands)				
North	0.1461	0.3592	0.1472	0.3103
	[0.095]	[0.297]	[0.095]	[0.287]
Centre	0.2106**	0.4025	0.1816*	0.2134
	[0.098]	[0.301]	[0.099]	[0.315]
Scientific Field dummies (Ref. Cat.: Biological sciences)				
Chemical Sciences	0.0873	0.15	0.1123	0.2256
	[0.101]	[0.354]	[0.099]	[0.321]
Mathematics & Physics	0.2442	0.2015	0.2956	0.3765
	[0.183]	[0.745]	[0.183]	[0.692]
Engineering	0.2864***	0.8695**	0.2826**	0.8614**
	[0.110]	[0.370]	[0.111]	[0.343]
Medical Sciences	0.0518	-0.0506	0.0494	-0.0342
	[0.146]	[0.494]	[0.144]	[0.450]
Cohort dummies (Ref. Cat.: 1930-1940 cohort)				
1941-1950 Cohort	-0.1144	0.1413	-0.1678	-0.1458
	[0.101]	[0.418]	[0.109]	[0.416]
1951-1960 Cohort	-0.2514	-0.0578	-0.3142	-0.4527
	[0.182]	[0.731]	[0.196]	[0.739]
1961-1970 Cohort	-0.5152**	0.2736	-0.6450**	-0.5059
	[0.259]	[0.964]	[0.281]	[1.002]
Constant	2.8069***	-1.05	3.1764***	1.1151
	[0.686]	[2.659]	[0.760]	[2.730]
Observations	133	133	133	133
Log-likelihood	-296.5207	-172.118	-294.4954	-167.8399
Wald χ^2	104.797(18)***	69.7802(18)***	138.1441(21)***	67.5499(21)***
Mc Fadden's Pseudo R^2	0.0887	0.1716	0.0949	0.1922

Notes: Robust standard errors are in parentheses. * p<0.10, ** p<0.05, *** p<0.01. Degrees of freedom of the Wald $\chi 2$ test are reported in parenthesis.

Table 7: Determinants of Knowledge and Technology Transfer (KTT) breadth and depth: Interaction among motivations (Model 3)

	KTT Breadth (3a)	KTT Depth (3b)
Learning	0.0257	0.134
	[0.027]	[0.103]
Mission	0.1007***	0.2367**
	[0.025]	[0.107]
Funding	0.0594**	0.1738
	[0.029]	[0.114]
Learning*Mission	0.0144	0.0101
	[0.020]	[0.074]
Learning*Funding	-0.0065	0.1393
	[0.020]	[0.094]
Mission*Funding	0.0137	0.2453**
	[0.024]	[0.107]
Learning*Mission*Funding	-0.018	-0.1026
	[0.019]	[0.079]
Gender	0.3007***	0.5778
	[0.102]	[0.360]
Age	-0.0209**	-0.0275
	[0.009]	[0.037]
Research Quality	0.0008	0.0866
	[0.023]	[0.085]
Public Funding	0.7175**	2.9765**
	[0.362]	[1.323]
Constant	2.7616***	-0.2982
	[0.715]	[2.859]
Observations	133	133
Log-likelihood	-296.0032	-168.2051
Wald χ^2	111.4533(22)***	89.6722(22)***
McFadden's Pseudo R^2	0.0903	0.1904

Notes: Robust standard errors are in parentheses. * p<0.10, ** p<0.05, *** p<0.01. Degrees of freedom of the Wald $\chi 2$ test are reported in parenthesis. Cohort, scientific fields, geographical and status controls have been included but are not reported for space reasons.

Table 8: Determinants of Knowledge and Technology Transfer (KTT) breadth and depth: Moderation effect of scientific productivity (Model 4)

	KTT Breadth (4.1a)	KTT Breadth (4.2a)	KTT Breadth (4.3a)	KTT Depth (4.1b)	KTT Depth (4.2b)	KTT Depth (4.3b))
Learning	0.025	0.0246	0.0423	0.1737*	0.1708*	0.0357
	[0.023]	[0.026]	[0.032]	[0.090]	[0.096]	[0.118]
Mission	0.0915***	0.0754*	0.0978***	0.2843***	0.1212	0.3031***
	[0.024]	[0.040]	[0.028]	[0.106]	[0.185]	[0.113]
Funding	0.0705	0.0540*	0.0506	0.4950***	0.2568**	0.2505**
	[0.050]	[0.031]	[0.031]	[0.179]	[0.127]	[0.123]
$Learning^2$	0.0148	0.0139	0.0142	0.0575	0.0453	0.0094
	[0.012]	[0.012]	[0.013]	[0.049]	[0.056]	[0.060]
$Mission^2$	-0.0240*	-0.0188	-0.019	-0.1146	-0.0689	-0.0507
	[0.013]	[0.014]	[0.013]	[0.077]	[0.080]	[0.072]
$Funding^2$	-0.0476*	-0.0533**	-0.0577**	-0.2437*	-0.2803*	-0.2728
	[0.028]	[0.027]	[0.028]	[0.144]	[0.154]	[0.169]
Star*Learning			-0.0545			0.1838
			[0.045]			[0.291]
Star*Mission		0.0596			0.3192	
		[0.049]			[0.262]	
Star*Funding	-0.0833			-1.0515***		
	[0.075]			[0.405]		
Gender	0.3218***	0.3173***	0.3074***	0.9200**	0.7004*	0.6494*
	[0.108]	[0.104]	[0.102]	[0.378]	[0.372]	[0.362]
Age	-0.0247**	-0.0248**	-0.0257***	-0.0328	-0.0289	-0.0368
	[0.010]	[0.010]	[0.010]	[0.036]	[0.037]	[0.036]
Research Quality	-0.0012	-0.0069	-0.0061	0.0384	0.0052	0.0248
	[0.024]	[0.025]	[0.026]	[0.102]	[0.107]	[0.104]
Public Funding	0.6257*	0.7790**	0.6043*	1.9804	2.1216	1.7434
	[0.344]	[0.386]	[0.350]	[1.291]	[1.424]	[1.270]
Constant	3.1101***	3.1297***	3.2344***	0.4027	0.5392	1.159
	[0.760]	[0.790]	[0.752]	[2.913]	[2.850]	[2.730]
Observations	133	133	133	133	133	133
Log-likelihood	-294.00	-293.97	-294.11	-161.51	-166.98	-167.06
Wald χ^2	166.17(24)***	166.90(24)***	144.25(24)***	101.14(24)***	68.44(24)***	67.33(24)***
McFadden's Pseudo R^2	0.10	0.10	0.10	0.22	0.20	0.20

Notes: Robust standard errors are in parentheses. * p<0.10, ** p<0.05, *** p<0.01. Degrees of freedom of the Wald χ2 test are reported in parenthesis. Cohort, scientific fields, geographical and status controls have been included but are not reported for space reasons

Table 9: Determinants of Knowledge and Technology Transfer (KTT) breadth and depth: Moderation effect of status (Model 5)

	KTT Breadth (5.1a)	KTT Breadth (5.2a)	KTT Breadth (5.3a)	KTT Depth (5.1b)	KTT Depth (5.2b)	KTT Depth (5.3b)
Learning	0.0247	0.0214	0.0785	0.1498	0.1331	1.4710***
	[0.024]	[0.024]	[0.184]	[0.095]	[0.094]	[0.525]
Mission	0.0921***	0.3181***	0.0927***	0.2883***	2.1099***	0.2725**
	[0.025]	[0.098]	[0.025]	[0.111]	[0.659]	[0.111]
Funding	0.0595	0.0473	0.0511	0.5259	0.2499**	0.2222*
	[0.084]	[0.031]	[0.032]	[0.426]	[0.125]	[0.125]
Learning^2	0.0135	0.0125	0.0124	0.0392	0.0308	0.0224
	[0.012]	[0.012]	[0.012]	[0.052]	[0.055]	[0.057]
Mission^2	-0.0218*	-0.0242*	-0.0217*	-0.0675	-0.1096	-0.086
	[0.013]	[0.014]	[0.013]	[0.067]	[0.093]	[0.069]
Funding^2	-0.0568**	-0.0550**	-0.0559**	-0.2983*	-0.2930*	-0.2904*
	[0.029]	[0.027]	[0.027]	[0.161]	[0.160]	[0.159]
Learning*Associate Prof.			-0.0554			-1.4438***
			[0.186]			[0.558]
Learning*Full Prof.			-0.0548			-1.2777**
			[0.187]			[0.551]
Mission*Associate Prof.		-0.2153*			-1.6423**	
		[0.120]			[0.736]	
Mission*Full Prof.		-0.2431**			-1.9400***	
		[0.100]			[0.684]	
Funding*Associate Prof.	0.0106			-0.0278		
	[0.096]			[0.519]		
Funding*Full Prof.	-0.0191			-0.4198		
	[0.086]			[0.456]		
Constant	3.2607***	3.1841***	3.1655***	2.1355	0.1661	0.1005
	[0.783]	[0.745]	[0.770]	[2.907]	[2.586]	[2.700]
Observations	133	133	133	133	133	133
Log-likelihood	-294.421	-293.299	-294.448	-166.448	-163.342	-164.999
Wald χ^2	140.6584(23)***	156.5128(23)***	153.2274(23)***	69.1314(23)***	105.3054(23)***	80.554(23)***
McFadden's Pseudo R^2	0.0951	0.0986	0.0951	0.1989	0.2138	0.2059

Notes: Robust standard errors are in parentheses. * p<0.10, ** p<0.05, *** p<0.01. Degrees of freedom of the Wald $\chi 2$ test are reported in parenthesis. All controls have been included but are not reported for space reasons.