Department of Economics and Statistics "Cognetti de Martiis"
Campus Luigi Einaudi, Lungo Dora Siena 100/A, 10153 Torino (Italy)
www.est.unito.it

Dipartimento
Economia e Statistica
Cognetti de Martiis

Working Paper Series

20/20

ACADEMIC ENGAGEMENT WITH INDUSTRY: THE ROLE OF RESEARCH QUALITY AND EXPERIENCE

ALESSANDRA SCANDURA and SIMONA IAMMARINO

Bureau of Research on Innovation, Complexity and Knowledge

UNIVERSITÀ DEGLI STUDI DI TORINO

The Department of Economics and Statistics "Cognetti de Martiis" publishes research papers authored by members and guests of the Department and of its research centers. ISSN: 2039-4004

Academic engagement with industry: the role of research quality and experience

Alessandra Scandura

Department of Economics and Statistics "Cognetti de Martiis", University of Torino

alessandra.scandura@unito.it

Simona Iammarino

Department of Geography and Environment, London School of Economics and Political Science

s.iammarino@lse.ac.uk

Abstract

This work explores the role of university department characteristics on academic engagement with industry. In particular, we investigate the role played by research quality and previous experience across different scientific disciplines. We test our hypotheses on a dataset of publicly funded university-industry partnerships in the UK, combined with data from the UK Research Assessment Exercises 2001 and 2008. Our data reveal a negative link between academic quality and the level of engagement with industry for departments in the basic sciences, and a positive relationship for departments in the applied sciences. Our results further show that the role of research quality for academic engagement tightly depends on the level of department previous experience in university-industry partnerships, notably in the basic sciences, where experience acts as a moderating factor. The findings of this work are highly relevant for policy makers and university managers, and contribute to the innovation literature focused on the investigation of the determinants of valuable knowledge transfer practices in academia.

Key words: academic engagement, academic quality, university-industry collaboration

JEL codes: I23, O30

1. Introduction

Universities are key agents of economic and social progress. Their mission has progressively been extended to interactions with industry, and with society more generally, beyond the traditional missions of teaching and research (e.g. Bercovitz and Feldman, 2006; Archibugi and Filippetti, 2017; Giuri et al., 2018). The role of universities so conceived has attracted considerable attention from scholars and policy-makers (e.g. Hsu et al., 2015; Trune and Goslin, 1998). As a matter of fact, university engagement in knowledge transfer and dissemination of research results ("third mission" activities) is investigated by various streams of the academic literature, including economics of innovation, economic geography, geography of innovation, and economics of science. University engagement activities take various forms, including employment channels, intellectual property rights related interactions, research collaboration, and informal direct/indirect contacts (see e.g. Geuna and Rossi, 2013; Rossi and Rosli, 2013). However, whilst university intellectual property-related activities and academic entrepreneurship have attracted major attention both within the academic literature and the policy community (Phan and Siegel, 2006, Rothaermel et al., 2007; O'Shea et al., 2008), other types of university-industry (U-I) interaction have become more prevalent (Perkmann et al., 2013). This is notably the case of research partnerships, which refer to a specific typology of university interaction with industry entailing firms and university joint research and financial effort within a specific collaborative project (D'Este and Iammarino, 2010; Scandura, 2016).

Many scholars have investigated the determinants of U-I partnerships (see e.g. Schartinger et al., 2002; Fontana and Geuna, 2006; D'Este and Iammarino, 2010; D'Este et al., 2013). Whilst the role of individual-level factors is rather well explored – albeit some characteristics, such as gender, are still overlooked (Filippetti and Savona, 2017) – the empirical evidence is scant about the context in which U-I partnerships occur, mostly with respect to the characteristics of the university departments involved (Perkmann et al., 2013). In particular, whilst the relevance of the research standing of academic departments has been investigated (see e.g. Tornquist and Kallsen, 1994; Mansfield, 1995 and 1997; Mansfield and Lee, 1996), its joint effect with other contextual factors remains mostly unexplored. In fact, it has been shown that research quality per se does not unambiguously affect any form of academic engagement (D'Este and Iammarino, 2010). Additional relevant determinants include physical proximity between academia and businesses, as well as other forms of proximities (e.g. cognitive, institutional, social) among interacting agents, along with specific characteristics of academia and firms (e.g. scientific discipline, firm sector and size). In particular, it is beyond doubt that the patterns in U-I partnerships deeply depend on the scientific discipline of academic departments (Mansfield and Lee, 1996; Bekkers and Bodas Freitas, 2008; D'Este and Iammarino, 2010). However, the empirical evidence is scant about the joint effect of research quality and scientific disciplines. A few contributions point to differences between hard sciences and humanities as well as between applied and basic sciences, suggesting that the effects of research quality and scientific disciplines on U-I partnerships may be interdependent (e.g. D'Este and Iammarino, 2010; Olmos-Penuela et al., 2014). Similarly, while cumulated experience in academic engagement has been shown to be a predictor of future engagement, its influence on the link between research quality and U-I partnerships is an underexplored issue in the literature (see e.g. Bozeman and Gaughan, 2007; Boardman and Ponomariov, 2009). In particular, whether the effect of research quality holds when academia cumulates experience in U-I interactions remains an open question. In this paper, we intend to fill these gaps and extend the existing literature in various directions.

Firstly, we investigate the role played by university department research quality for the level of academic engagement in U-I partnerships, by distinguishing between departments in basic and applied hard sciences. Specifically, we test the hypotheses that academic quality is negatively related to U-I partnerships in basic sciences departments, and positively related to it in applied sciences departments. Our hypotheses rest on various arguments, including different motivations attracting companies, resource availability at higher/lower quality universities, incentives for researchers in top departments, and characteristics of the knowledge generated inside basic and applied sciences departments. Secondly, we focus on department-level cumulated experience in U-I partnerships as a joint determinant of academic engagement together with research quality. We posit that department past experience weakens the negative relationship between academic quality and engagement in basic sciences, while it amplifies the positive link in applied disciplines. We base our hypotheses on the argument that department experience in academic engagement influences their capability to fruitfully establish and maintain connections with companies and that the extent of such influence changes across scientific disciplines.

To address these issues, we carry out regression analyses on a dataset of U-I partnerships funded by the UK Engineering and Physical Sciences Research Council (EPSRC), combined with data on academic institutions from the UK Research Assessment Exercises (RAE) developed by the UK Higher Education Funding Councils. In the empirical analysis we account for academic departments' engagement in U-I partnerships by considering the precise level of financial resources involved. In doing so, we overcome one of the limitations in extant research, namely the lack of information on the amount of financial flows at stake (see e.g. Perkmann et al., 2011). Yet, income flows that university departments receive for their knowledge transfer activities may reflect the value placed by external partners on academic knowledge, thus providing a measure of the economic value created through knowledge transfer (Rossi and Rosli, 2013). As a consequence, our empirical analysis is likely to inform about the determinants of valuable academic engagement practices.

The paper is organised as follows: we review the relevant literature and develop our empirical hypotheses in section 2; in sections 3 we illustrate our data sources, variables and methodology; the empirical results along with robustness checks are presented in section 4; finally, we discuss our findings and offer some concluding remarks in section 5.

2. Literature and hypotheses development

2.1 University engagement with industry

In the last decades, views changed regarding the role of universities in the economy: from being seen as *ivory towers* where academics mainly performed research in isolation, universities became actively engaged with external stakeholders (Bodas Freitas et al., 2011). In order to compensate for the decrease in government funding for military-oriented research and for a more general reduction of government intervention in the economy, universities became more and more interested in collaborating with companies (Geuna and Muscio, 2009). Relatedly, they also assumed a role in stimulating regional economic development and innovation processes through local spending on wages and services and local knowledge spillovers from research (Geuna and Muscio, 2009; Lawton Smith and Bagchi-Sen, 2012). Universities able to participate into the network of knowledge interactions are crucial sources of external knowledge to firms. Moreover, the shift towards the knowledge based models of economic development together with the paradigm of the entrepreneurial university (Etzkowitz et al., 2000), legitimate universities to pursue their own profits, aside acting as a central agent in the process of knowledge production and generation (Lawton Smith and Bagchi-Sen, 2006). As a consequence, nowadays many universities establish and nurture links with knowledge users and engage in activities facilitating technology transfer.

Together with commercialisation activities, such as patenting and academic spinoffs, universities carry out a wide range of collaborative initiatives, often identified as *academic engagement*. As defined by Perkmann et al. (2013), academic engagement refers to inter-organisational collaboration that links universities with other organisations, especially firms, and includes both formal activities (e.g. collaborative research, contract research and consulting) and informal activities such as networking with practitioners. Although there is extensive research on university intellectual property activity and academic entrepreneurship, it is widely recognized that other academic engagement activities are more pervasive (Perkmann et al., 2013). Among academic engagement activities, U-I collaborative research partnerships stand out: they represent a specific channel of inter-organisational knowledge flows and potential spillovers from (and to) academic research, aimed at carrying out research and development (R&D) projects, mainly involving pre-competitive and basic research and often subsidized by public funding (OECD, 1998, 2002; D'Este and Fontana, 2007; D'Este et al., 2013; Scandura, 2016). U-I research partnerships represent one of the most frequent policy instruments put in place by national and policy-makers to foster pre-competitive research and U-I knowledge transfer activities (OECD, 1998, 2002; Fisher et al., 2009; D'Este and Iammarino, 2010).

2.2. The role of research quality

The vast empirical evidence on the determinants of academic engagement and, specifically, on U-I partnerships, shows that knowledge and technological proximities, as well as geographical proximity, commercial orientation of universities, availability of financial resources and quality of academic research are some of the most significant drivers (e.g. Schartinger et al., 2002; Fontana and Geuna, 2006; D'Este and Iammarino, 2010; Laursen et al., 2011; Perkmann et al., 2013; Crescenzi et al., 2017). In particular, scholars have devoted a great deal of attention to the role of research quality. In their seminal contributions, Mansfield (1995, 1997) and Mansfield and Lee (1996) show that academic research excellence is a driver for companies that are interested in carrying out joint research activities with universities, thus seeking proper support for the technology issues faced during the innovation process. Similarly, Tornquist and Kallsen (1994), show that the research output of high quality universities has a greater potential for industrial application, hence meeting the research needs of innovative companies. At the individual level, a number of contributions show that the most successful academics are often those who engage the most in joint research with industry (see e.g. Gulbrandsen and Smeby, 2005; Bekkers and Bodas Freitas, 2008; Haeussler and Colyvas, 2011; Crescenzi et al., 2017).

However, the net effect of academic quality on participation in U-I collaborative activities has also been found to be negative. Mansfield and Lee (1996) find that less prestigious universities generate findings that are considered highly important by firms, hence underscoring that second-tier universities do substantially contribute to industrial innovation. In the same vein, Laursen et al. (2008) find that low quality universities are best placed to collaborate with local R&D intensive firms. Focusing on individual academics, D'Este and Patel (2007) show that scientists from departments that are poorly rated seem to engage in a wider range of interactions with industry, but this is only valid in the case of applied disciplines. Comparing the university and individual levels of analysis, Ponomariov (2008) finds that the role of academic quality is generally positive at the institutional level, while the higher the average academic quality of an institution, the lower the propensity of individual scientists to interact with the private sector. Perkmann et al. (2011) find support for a negative relationship between research quality at department level and applied forms of academic engagement in the social sciences. According to D'Este et al. (2013), the pursuit of high academic excellence is neither impaired nor enhanced by business engagement across UK academic departments.

To sum up, the empirical evidence on the relationship between academic quality and collaboration with industry appears mixed (Perkmann et al., 2013). Notably, the reasons for a non-univocal relationship between research quality and academic engagement are partly rooted in the scientific disciplines of the academic department. As a matter of fact, substantial disciplinary effects stand out in the extant literature on academic engagement, including the specific case of research partnerships (see e.g. Schartinger et al., 2002; Bekkers and Bodas-Freitas, 2008; D'este and Iammarino, 2010). The affiliation to a scientific discipline shapes the norms relevant for researchers as these are the rules of conduct that prevail within the so-called invisible colleges in which academic scientists operate (Crane, 1972). Thus, the scientific discipline of an academic department is an important factor affecting the typology of engagement with industry (Bekkers and Bodas Freitas, 2008; Martinelli et al., 2008). In particular, as opposed to basic sciences, applied fields of research (e.g. engineering) make collaboration or engagement in entrepreneurial activities more likely (Bekkers and Bodas Freitas, 2008). Similarly, the extensive review of the literature presented in Perkmann et al. (2013) documents that departments specialised in applied disciplines are generally found to be highly engaged, especially in commercialisation activities. While extant research shows how scientific disciplines affect the extent and typology of interactions between academia and industry, only limited evidence informs about the specific link between research quality in a given discipline and academic engagement. One of the few exceptions is the study by D'Este and Iammarino (2010), which highlights that research quality is slightly more important for the frequency of research partnerships in basic sciences, with respect to applied ones.

In the present work, we aim at testing disciplinary effects in the relationship between departmental academic quality and collaboration with industry in publicly funded R&D partnerships. While the reasons for a positive relationship between research quality and academic engagement are rather clear-cut, mostly involving the argument that companies are motivated by the opportunity to access top quality research that is highly applicable in their R&D activities (Feller and Roessner, 1995; Bishop et al., 2011), the explanation for a negative relationship is less clear. Extant literature put forward two main reasons for that. One the one hand, low resource availability at lower quality universities may motivate (top) academics in these schools to seek industry collaboration in order to acquire research funds (Perkmann et al., 2013). In such cases, a positive link between quality and U-I interaction may still exist at the level of the individual scientist, whereas the link is negative at department/institution level. On the other hand, the effect of a more prestigious research environment may be that academics in top departments perceive greater incentives to engage in blue sky research rather than to engage in interactions with industry (Ponomariov, 2008). In other words, high levels of academic research quality may mirror a highly competitive academic environment that could limit scientists' ability and willingness to interact with business. In addition, while top universities have excellent research capacities, less prestigious institutions may well have a comparative advantage "at the stage where firms need to interact with university personnel who are willing to focus on their immediate problems and help them apply their knowledge" (Mansfield and Lee, 1996: 1057).

The divergence between norms, language, purposes and incentive structures between the academic and the business worlds is likely to be particularly strong when the academic partner is most oriented towards upstream blue-sky research as compared to research closer to the context of application (Dasgupta and David, 1994). Relatedly, the characteristics of the knowledge stemming from research activities in a given scientific discipline play a key role in shaping the link between academic excellence and collaboration with industrial partners (Meyer-Krahmer and Schmoch, 1998). Top quality research in the basic sciences is characterised by low marketability and applicability because the knowledge generated mostly originates from blue-sky research that is far from industrial application: such knowledge is most often at the frontier, it is highly tacit, hence less codifiable by those who do not command the field of investigation (Dasgupta and David, 1994; Martin and Scott, 2000; Aghion et al., 2008). In fact, the products of science-based disciplines can usually only be indirectly analysed and produced by the mediation of instruments and theoretical considerations (Meyer-Khramer and Schmoch, 1998). Companies are generally only scarcely interested in this typology of research because of its high riskiness and intrinsic low appropriability: given companies' profit maximisation objectives, they will be less interested in new knowledge that is likely to be less marketable (Aghion et al., 2008). On the contrary, engineering-related disciplines are by definition closer to the business community (Meyer-Khramer and Schmoch, 1998). Moreover, the artefacts in engineering sciences are tangible and thus open to direct, experience-based manipulation, as opposed to the products of basic sciences. Therefore, high-quality research pursued in fields such as engineering is highly applicable for industrial purposes as it generates knowledge with high technical and market related content (Meyer-Khramer and Schmoch, 1998). Based on these arguments, we posit the following hypotheses:

Hp 1a: The higher the research quality of basic disciplines departments, the lower the extent of engagement with industry.

Hp 1b: The higher the research quality of applied disciplines departments, the higher the extent of engagement with industry.

2.3 The role of cumulated experience in academic engagement

Notwithstanding the importance of research quality, even across different scientific domains, this alone cannot fully explain the occurrence and the level of university-business interaction. Indeed, past research has extensively focused on contextual factors that may affect the involvement of universities with firms, including geographical proximity (e.g. D'Este and Iammarino, 2010; D'Este et al., 2013), department and university size (Perkmann et al., 2013) and previous experience in academic engagement. With respect to the latter, studies carried out at the individual level find that the attitude of academics towards industry as well as their collaborative behaviour are positively influenced by having collaborated in the past with companies (see e.g. Van Dierdonck et al., 1990; D'Este and Patel, 2007). Similarly, the likelihood of scientists' participation in academic engagement activities is positively influenced by previous experience in patenting and other commercialisation activities (Bekkers and Bodas Freitas, 2008). In addition, past empirical works show that the likelihood of scientists' interaction with industrial partners is particularly and positively related to the extent of involvement in grant-sponsored joint research (Bozeman and Gaughan, 2007; Link et al., 2007). In fact, academic scientists who are highly active and successful in procuring grants involving firms are more likely to maintain fruitful research agendas, which include those of interest to industry (Ponomariov, 2008). At the institutional level, Schartinger et al. (2002) note that when academic departments in a certain field of science have a high level of experience in external interactions, notably with industry, both institutional and individual barriers to knowledge interactions are likely to be less important than in the case of fields of science with little experience so far (Schartinger et al., 2002). Besides lowering barriers, previous knowledge interactions by university departments will enlarge the network of potential contacts with industrial partners and hence increase the likelihood of future collaborations. Therefore, academic departments that have established collaborations with companies mirror an institutional environment in favour of interactions with industry (D'Este and Patel, 2007).

A positive association between past experience and engagement in joint research activities between companies and universities may be driven by various factors from the company side as well. As already noted, "industrially" fruitful academic research agendas, lowered barriers to knowledge interactions, and enlarged network of contacts are among the key motives. In addition, companies tend to look positively at academic scientists, as well as departments and institutions, who have experience in procuring grants from public funding agencies, as this mirrors scientists' ability to secure funding allocated via competitive bids (including writing effective applications, gathering high quality human resources, establishing links with industrial partners, etc.). More generally, cumulated experience represents for companies an indirect measure of the "organisational climate" (Ponomariov, 2008): while universities with relatively low experience with industry may develop ad hoc and less routinised interactions, those with high levels of experience might be characterised by a rooted culture of interactions, hence resulting in an organisation climate where knowledge linkages with industrial partners are "sanctioned, accepted, or even expected" (Ponomariov, 2008: 490).

To the best of our knowledge, evidence on previous experience as a contextual determinant of academic engagement together with research quality is scanty. As a matter of fact, the literature that we briefly revised does not account for academic research quality when estimating the relationship between the amount of cumulated academic experience in university-industry interactions and future engagement. We are particularly interested in the existence of simultaneous effects of department experience and research quality because the literature extensively shows that both factors play a major role in academic engagement. However, the same literature shows still mixed evidence about the net role of research quality. For this reason, we argue that the influence of research quality on academic engagement depends on the level of cumulated experience. We develop our arguments taking into account the disciplinary-effects previously underscored as the role of research quality within different scientific domains may also depend on the extent of department experience.

We posit that cumulated experience negatively moderates the role of academic research quality in basic sciences departments and positively moderates it in the case of applied sciences academic departments. Therefore, we expect that past experience weakens the negative relationship between quality and engagement in basic sciences and strengthens the positive link between quality and engagement in applied domains. Given the relevance of past experience in U-I interactions, we expect it to compensate for the lack of attractiveness that basic sciences departments of high quality may have for companies. This is likely to be driven by lowered barriers to interactions and a favourable organisational climate linked to cumulated academic experience in U-I interactions, as well as to a documented track record of fruitful applications of research outputs (Schartinger et al., 2002; Ponomariov, 2008). In the case of applied sciences departments, research quality and experience both have a positive relationship with academic engagement, and we expect that they reinforce each other. In addition, such reinforcement may be linked to the presence of past U-I connections that lead to strengthening existing collaborations while establishing new ones. Therefore, we hypothesise the following:

Hp 2a: Experience mitigates the negative relationship between research quality and academic engagement in basic sciences.

Hp 2b: Experience amplifies the positive relationship between research quality and academic engagement in applied disciplines.

3. Data, variables and methodology

3.1 Data sources

The data for the empirical analysis consists of a set of U-I research grants awarded to UK Universities by the Engineering and Physical Sciences Research Council (EPSRC) between 1992 and 2007, combined with university and department level information gathered from the UK Higher Education Funding Councils' Research Assessment Exercise (RAE) 2001 and 2008. The EPSRC is one of the UK research councils responsible for administering public funding for research in the UK. It is responsible for funding research in the areas of engineering and physical sciences, including all the engineering fields, chemistry, mathematics and computer science, but it also welcomes research proposals that span the remits of other research councils, such as biology, social science or medical-related research. The EPSRC data include information on the number of U-I projects won by each department, the size of the grants awarded by the EPSRC, and the amount of cash or in-kind support (or a combination of both) provided by companies to the joint projects. We combine this data with information on departments and universities collected from the RAE 2001 and 2008. The RAE, nowadays called Research Evaluation Framework (REF), is an evaluation exercise carried out in the UK approximately every 5 years, jointly by the Higher Education Funding Council for England (HEFCE), the Scottish Funding Council (SFC), the Higher Education Funding Council for Wales (HEFCW) and the Department for Employment and Learning, Northern Ireland (DEL). The primary purpose of the RAE is to provide ratings of research quality to be used by the UK higher education funding bodies in determining the main block research grants for the institutions they fund. For evaluation by the RAE 2001 and 2008, universities submitted the results of their research activity for all or some fraction of the research staff in their departments, within 68 so-called Units of Assessment (UoA), corresponding to 68 subject research areas. Submission to the RAE is not mandatory but incentives for participation are high as public research funding tightly depends on the assessment. Besides department ratings, the RAE provides other information, including department size (count of staff) and amount as well as sources of research funding received during the period under evaluation.[1]

We link each academic department involved into EPSRC sponsored partnerships to a UoA[2] and then merge the data from the RAE 2001 and 2008, so to obtain information on two points in time for each department. The final dataset includes 280 university departments that took part to at least one EPSRC university-business partnership both in the time period preceding the publication of the RAE 2001 (1992-2000) and in the years preceding the publication of the RAE 2008 (2001-2007).[3]

3.2 Dependent variable

We measure U-I collaboration by the volume of funding that university departments receive from companies in the more recent time period under investigation (2001-2007). We consider the total cumulated level of funding in the main analysis, while the average amount of funding per project will be employed for a robustness check. By accounting for the level of funding assigned and reported by the funding agency, we overcome existing limitations related to the use of indirect proxies of U-I

---

[1] The use of RAE rankings for the purpose of evaluating academic quality has both pros and cons. These rankings have been extensively used in the academic literature focused on UK research quality (see e.g. McGuinness, 2003; Abramovsky et al., 2007; D'Este and Patel, 2007; Ambos et al., 2008; D'Este and Iammarino, 2010; Perkmann et al., 2011). On the one hand, RAE results are considered reliable because they follow an expert review process conducted by assessment panels, whose members are nominated by a wide range of organisations, including research associations, professional bodies and those representing industrial, business and other research users. On the other hand, they may only provide partial and imperfect information about the overall quality of Higher Education Institutions for various reasons. In the first place, panels' judgments, although made by experts who command a generally high level of respect, are subjective and hard to validate. Secondly, and perhaps more importantly, RAE scores are based on refereed publications, therefore departments that are more oriented towards the production of publishable research may be advantaged. On the contrary, departments that are more focused on teaching activity and/or engaged with private sector activities may be valued less. As a matter of fact, after RAE 2001 results were published, some academics felt that their work was validated whereas others suggested that RAE failed to account for high-quality strategic and applied research (Barker, 2007). Moreover, interdisciplinary areas also seemed to be discriminated against, although it is not easy to find evidence of this (Barker, 2007). Therefore, RAE and similar based measures should always be employed and interpreted with caution, given that they are an imperfect measure of academic standing.

[2] Most academic departments clearly correspond to a given UoA (e.g. departments of civil engineering, biological sciences, physics, etc.); in some cases, a choice had to be made on the most appropriate UoA for a given department, notably for interdisciplinary departments (e.g. departments of chemical and biological sciences). The choice was made based on the distribution of academic staff across disciplines inside a given department, hence assigning a department to the UoA most pertinent to the majority of the staff. Information for such choice was obtained from the RAE as well as from manual searches on academic department webpages.

[3] Only 3 departments did not participate in the second period.

collaboration (Perkmann et al., 2011), including self-reported measures lacking reliability and secondary data provided by HEIs often not distinguishing the type of collaborative scheme involved. Importantly, the amount of resources provided by private partners within collaborating projects specifically inform about private financial flows at stake, hence providing a measurable account of the value of university knowledge for industry. The mean value of the newly created dependent variable, *IndFund*, in the time period 2001-07 is 1.5 million pounds, but it ranges from 0 (3 departments) to 15 million pounds (std. dev. 2.7 million) (see Table 1).

[Table 1 about here]

3.3 Independent variables

We exploit the quality profiles published in the RAE 2001 to build our measures of department-level quality. The submission of each department to the RAE 2001 was rated on a seven-point scale from 1 to 5*, with 5* being the highest score, indicating that research quality achieved international excellence in more than a half of the departments' submitted activities, and the remaining activities reached national excellence. The original scale was 1, 2, 3b, 3a, 4, 5 and 5* (see Table 2). While none of the departments received the lowest rating, over 50% (corresponding to 121) of departments in our sample were given the highest evaluation (5 and 5*).[4] To synthesize the rating while accounting for its distribution in our sample, we worked out two variables. The first one is a dummy indicator (*TopQual*) that takes value 1 if a department has obtained a rating of 5 or 5*. The independent variable so constructed allows to clearly distinguish between low-medium quality departments and the top ones. However, given the concentration of departments in the highest ratings in our sample, we build an additional measure that allows to distinguish between departments whose research quality is extremely high from those whose quality is high. More specifically, we work out three quality levels measured through binary indicators, each taking value 1 if the original RAE 2001 rating equals 2-3b-3a-4 (*QualLevel_1*), 5 (*QualLevel_2*), and 5* (*QualLevel_3*) respectively. The three dummies identify departments of low-medium research quality (*QualLevel_1*=1 for 47.5% of departments), of high research quality (*QualLevel_2*=1 for 38.57% of departments) and of very high research quality (*QualLevel_3*=1 for 13.93% of departments). We employ *QualLevel_2* and *QualLevel_3* as independent variables in the regression analyses, while *QualLevel_1* is the reference category, hence omitted from the model.

[4] This distribution shows that our sample displays a higher than the average research quality, as compared to the whole sample of UK Universities' departments, where the share of UoA receiving 5 or 5* is 37% (source: RAE2001).

[Table 2 about here]

Besides academic quality, to test hypotheses 1a and 1b we exploit two binary variables indicating whether departments belong to basic or applied sciences at the time of the RAE 2001 submission. The variable *Basic* (32.86%) equals 1 for chemistry, physics, maths and statistics, while *Applied* (59,64%) is equal to 1 for all the engineering related sciences[5], computer science and environmental sciences (see Table 3). The remaining departments belong to the field of social sciences and humanities (5.36%)[6] and medical sciences (2.14%)[7]: since these are a minority in our sample, we group them under the binary indicator *OtherDisc* (7.5%). As far as research quality is concerned, the distribution of the quality indicators across basic and applied disciplines is slightly different (see Table 4). While the majority of basic sciences departments (66%) was given a high to highest quality rankings, less than half of applied sciences departments (49%) received similar ratings.

[Tables 3 and 4 about here]

In order to test hypotheses 2a and 2b, we measure departmental cumulated experience in academic engagement, using the volume of EPSRC funds awarded in previous years for U-I partnerships (*Experience*). This variable measures experience that departments gain in carrying out research funded by the EPSRC, hence it helps understanding whether and to what extent factors such as lowered barriers to interactions, supportive organisational climate inside academia and the ability to mobilise resources resulting from past involvement in grant-sponsored joint research, affect the role played by research quality within a given scientific field.[8] The mean volume of funding received from

[5] General, chemical, civil, electric, mechanic, and metallurgy and materials engineering.

[6] Arts, architecture, planning, management, and communication studies

[7] Medical and pharmaceutical studies, and biology

[8] Past EPSRC funding may be related to academic standing because better departments may have higher interaction with public funding agencies, hence capturing a very similar effect to that of *Research quality* on industry funding. Similarly, the quality rating of each department may be influenced by having participated to EPSRC projects. However, we believe this not to be a major concern in our analysis due to the ways public funding for research is allocated to UK universities. During the time period under analysis, public research funding in UK higher education was administered under a 'dual support' system, according to which higher education funding councils provide the so called block grant funding to support the research infrastructure, and the Research Councils as well as other entities (e.g. charities, the European Union and government departments) provide grants for specific research projects and programmes. The block grant funding was allocated on the basis of research quality, as evaluated by the higher education funding councils themselves in the Research Assessment Exercise. Ad-hoc grants for specific projects are instead allocated on the basis of different criteria. In particular, Research Councils employ independent expert peer review, consisting in the assessment for scientific quality by senior academics or peers from the UK and overseas. Therefore, the amount of EPSRC funding that each department received between 1992 and 2000 is supposed to be independent from research quality in those years, as evaluated by the RAE 2001. Moreover, the RAE ratings was published in 2001, whereas we only include EPSRC funding received up to 2000 as a measure of previous experience. Therefore, it is hardly likely that research quality and the level of EPSRC funds both measure academic standing, thus being directly related to eachother.

the EPSRC by each department for U-I projects that took place in years 1992-2000 is 2 million GBP (std. dev. 2.8 million GBP) (see Table 1). When looking at the level of cumulated experience across quality levels and scientific disciplines of academic departments, we observe an upward trend with increasing quality (Table 5, top panel) and larger experience among applied sciences departments with respect to basic ones (Table 5, bottom panel).

[Table 5 about here]

3.4 Control variables

We include a number of controls in the attempt to properly isolate the relationships between the dependent and independent variables (Table 1). In the first place, in order to account for other streams of funding that each department received from the private sectors and that may be related to the volume of funds raised from industry through the EPSRC collaboration schemes, we control for the level of total private funding obtained in the period 1992-2000 ($TotIndFund$). Secondly, we control for the amount of public funding received in the years 2001-2008, including streams of funds from the government and the Research Councils, but excluding those received by the EPSRC ($PublFund$). We expect both $TotIndFund$ and $PublFund$ to be positively related to the dependent variable since departments that raise funds from various sources are also likely to raise higher levels of funds specifically from companies (Bozeman and Gaughan, 2007; Boardman and Ponomariov, 2009). Thirdly, we control for department size by adding the count of research active staff in the department at the time of the RAE 2001 submissions ($Size$). We expect larger departments to access higher amounts of industry funding because of a likely larger pool of researchers engaged in collaboration with industry.

Importantly, we also introduce a set of binary indicators to account for the geographical location of the academic departments under investigation. The following region level dummies are included: East Midlands, East of England, London, North East, North West, Northern Ireland, Scotland, South East, South West, Wales, West Midlands and Yorkshire and the Humber. These captures region level factors that may affect the level of academic engagement with industry, including: local exogenous shocks, such as regulatory changes; the establishment of new companies, which enlarges the pool of firms to be potentially involved into U-I knowledge transfer; regional economic conditions, such as local innovative firms' absorptive capacity; quality of the labour market; and the implementation of new regional as well as national policies (Lawton Smith and Bagchi-Sen, 2012). In addition to location dummies, we add to the list of control variables the mean distance (in Km) between universities and collaborating firms calculated on the sample of partnerships occurred in the period

1992-2000 (*Dist*). The average geographical distance between universities and firms allows to check for the role of geographical proximity as a predictor of future collaborations. Descriptive statistics for all variables are presented in Tables 1-5, while the correlation matrix is reported in Table A.1 in Appendix A.

3.5 Methodology

We are interested in estimating the determinants of U-I collaboration. Specifically, we estimate two models that allow to test hypotheses 1a and 1b, and hypotheses 2a and 2b, respectively. In the first model, we test the interaction effect between research quality and the basic or applied sciences dummy variables. This allows to investigate whether departmental academic standing is negatively related to engagement with industry for basic sciences departments and positively related to that for applied sciences departments. In the second model, we run a split sample analysis on the two sub-samples of basic (N=92) and applied (N=167) disciplines departments in order to test the interaction effect between research quality and cumulated departmental experience, as per hypotheses 2a and 2b. By doing so, we intend to specifically test the argument that experience has a moderation effect on research quality that differs across scientific domains.

Since the dependent variable is continuous, we estimate OLS regressions with robust standard error to account for potential heteroskedasticity of the error terms (Angrist and Pischke, 2008). In order to reduce endogeneity concerns with respect to our independent variables, we exploit the two time periods that resulted from combining the EPSRC dataset with the RAE 2001 and 2008 (1992-2000 and 2001-2007). Therefore, we estimate the extent of U-I collaboration during years 2001-2007 as dependent on academic standing, scientific disciplines, experience and other control factors during the 1992-2000 period. We test for the presence of multicollinearity using Variance Inflation Factors (VIFs) for all model specifications and the results are satisfactory. The VIFs are always fairly low (below 2) with the exception of the interaction and interacted terms. Given the skewness of some of the continuous variables, we transform all of them through an inverse hyperbolic sine transformation that allows to linearise their trends, similarly to a logarithmic transformation, but avoid losing zero observations.[9]

[9] This is an alternative to the Box-Cox transformations, defined by the following formula: inverse y = log[yi + (yi^2 + 1)^1/2]. Except for very small values of y, the inverse sine can be interpreted as a standard logarithmic variable. However, unlike a logarithmic variable, the inverse hyperbolic sine is defined at zero (Johnson, 1949; Burbidge et al., 1988; MacKinnon and Magee, 1990).

4. Results

4.1 Main results

Tables 6 and 7 show the main findings. In Table 6 we present the results of the OLS regressions testing hypotheses 1a and 1b, while the results of the split sample analysis carried out to test hypotheses 2a and 2b are shown in Table 7. Columns (1) and (2) in Table 6 include the binary indicator *TopQual* as a measure of department level academic quality, along with its interactions with the variables *Basic* (Col. (1)) and *Applied* (Col. (2)), respectively. In columns (3) and (4) research quality is measured with the dummy variables *QualLevel_2* and *QualLevel_3*, and their interactions with the *Basic* and *Applied* dummies are added to test hypotheses 1a and 1b. Similarly, in Table 7 we test hp 2a and 2b exploiting *TopQual* and its interaction with *Experience* in columns (1) and (2); and *QualLevel_1* and *QualLevel_*2, along with their interactions with *Experience*, in columns (3) and (4).

[Tables 6 and 7 about here]

The academic standing of UK universities is positively and significantly linked to the level of industry funding raised through EPSRC U-I partnerships, as can be noted from the coefficients of *TopQual* and *QualLevel_1* and *QualLevel_2* in columns (1) and (3) of Table 6. However, the additional effect of quality for departments of basic sciences (*TopQual*Basic*) appears to be negative and significant (at 5% level), while it is positive and highly significant for departments of applied disciplines (*TopQual*Applied*) (at 1% level). Similarly, the effect of increasing quality levels, with respect to the baseline *QualLevel_1*, is increasingly negative for departments in the basic sciences and increasingly positive for those in the applied sciences, as the coefficients of the interaction terms in columns (3) and (4) show. Therefore, our data suggest that academic research quality negatively drives the extent of engagement with industry among departments of basic sciences, as postulated in hypothesis 1a, while it drives it positively for departments in applied sciences, as argued in hypothesis 1b. The level of cumulated experience (*Experience*) is positively and significantly related to industrial funding raised by academic departments, hence supporting the argument that the former may play a key role in facilitating the link between research quality and academic engagement. As a matter of fact, the results from the split sample analysis displayed in columns (1) and (3) of Table 7 show that experience positively moderates the influence that academic quality has on basic sciences departments' engagement with industry, hence mitigating the negative relationship ascertained in Table 6, confirming hypothesis 2a. Therefore, our data suggest that the larger the extent of cumulated experience in academic engagement among basic sciences departments, the lower the influence of academic research quality on industrial funding obtained through U-I collaborations. Instead, the amplification effect of experience postulated in hypothesis 2b with respect to applied sciences departments is only qualitatively confirmed, in that the coefficients of the interaction terms in columns (2) and (4) are positive but insignificant.

Among the control variables, it is worth noticing the positive and significant coefficient of *TotIndFund* in Table 6, showing the tight relationship between various sources of funding from industrial partners, and the negative link between geographical distance and the dependent variable in Table 7, proving that importance of physical proximity for U-I collaborations in basic sciences. The location dummies show that only few regions do better than the baseline category (*London*) in terms of engagement with industry, which may be driven by few key departments in universities there located.

4.2 Robustness checks

In order to check the robustness of our results, we carry out two sets of regressions. First, we replicate the regressions displayed in Tables 6 and 7 employing a different dependent variable. We modify the main dependent variable *IndFund* by dividing it for the count of collaborative projects that each academic department joined in the time frame 2001-2007, hence obtaining the average amount of industrial funding received per grant (*IndFundGrant*). The second set of regressions make use of a differently coded measure of departmental academic standing, so to check the sensitivity of the results with respect to the previously employed measures of research quality. To construct a new variable, we exploit the median value of the original RAE 2001 rating, after transforming it to a proper 7-point scale variable.[10] Hence, we work out a binary indicator called *TopQualNew* equalling 1 for departments whose rating is above the median value, 0 otherwise. Given the rather different distribution of the RAE 2001 rating across disciplines, we exploit the median of each sub-group of departments (basic sciences, applied sciences, social sciences and humanities, and medical sciences).[11]

The results shown in Tables 8 and 9 are highly in line with those from section 4.1, with the exception of a slightly different magnitude of the coefficients. Therefore, the first set of the robustness checks

[10] The original RAE 2001 rating (1, 2, 3b, 3a, 4, 5, 5*) becomes a 7 point scale (1, 2, 3, 4, 5, 6, 7), from which it is possible to work out its median value.
[11] The tabulation of *TopQualNew* shows that 107 academic departments have received a higher than the median RAE 2001 ranking.

implemented confirms a negative relationship between research quality and academic engagement in the basic sciences (Hp 1a), a positive relationship in the applied sciences (Hp 1b), and a moderation effect of experience on departmental quality in the basic sciences only (Hp 2a).

[Tables 8 and 9 about here]

Table 10 shows the results of the robustness check implemented after creating the dichotomous indicator *TopQualNew*. A negative relationship between industrial funding for U-I collaboration and academic standing for departments of basic sciences is confirmed, along with a positive relationship for the departments of applied disciplines. The moderation effect of cumulated experience in academic engagement is only qualitatively confirmed, as the coefficients of the interaction terms in columns (3) and (4) are positive but not statistically significant.

[Table 10 about here]

5. Discussion and conclusion

This paper investigated the relationship between university departments' characteristics and academic engagement with businesses in the form of U-I collaboration. We focussed on the role of the quality profile of academic departments and on their cumulated experience in academic engagement as determinants of the extent of involvement in U-I collaboration. Crucially, we postulate that the role of both factors is tightly linked to the scientific disciplines of academic departments, specifically considering differences between basic and applied hard sciences. The investigation of such issues is grounded on the pervasive role that U-I interactions have acquired in the current knowledge-based competitive context, where academic institutions are undoubtedly considered key agents of technological, scientific and economic progress, and companies rely more and more on the scientific output of academic research activities to compete in the globalised markets.

The findings show a negative relationship between the research standing of basic-sciences academic departments, as measured by the RAE 2001, and the extent of involvement in U-I collaboration with companies – measured by the volume of private funding injected into U-I research partnerships during the period 2001-2007. On the contrary, a positive link holds in applied-sciences departments. Finding a negative relationship between research quality and academic engagement contradicts most extant research, but is in line with few previous studies that find support for a negative relationship in specific contexts (Mansfield and Lee, 1996; D'Este and Patel, 2007; Ponomariov, 2008; Perkmann et al., 2011). Low resource availability at lower quality universities may push researchers to seek industry collaboration in order to acquire research funds (Perkmann et al., 2013), whilst the effect of a more prestigious research environment may be that academics in top departments perceive greater incentives to engage in blue sky research. A positive link between the quality profile of applied sciences academic departments and their engagement in research activity with industrial partners is in line with empirical evidence showing that companies are highly motivated in interacting with academia by the opportunity to gain access to applicable academic research outputs (Feller and Roessner, 1995; Bishop et al., 2011).

Moreover, the analysis supports and extends the scant empirical evidence on the key role of experience in academic engagement, by showing that it acts as a moderating factor in the relationship between research quality and U-I collaboration. In particular, we find that the higher the level of departmental cumulated experience in academic engagement, the weaker the negative relationship between research quality and U-I collaboration in the basic sciences, while we do not find significant moderation effects of experience with respect to the applied sciences. Arguably, the effect of experience is not pivotal in the case of applied sciences departments, where a strong positive relationship between research quality and academic engagement is likely to hold despite previous U-I interactions. On the contrary, the acquisition of experience at department level may represent an incentive for companies, even when research is characterised by low market applicability as in basic sciences departments, because it lowers barriers to interactions and creates a favourable institutional environment (Schartinger et al., 2002; D'Este and Patel, 2007; Antonioli et al., 2017).

The analysis here presented is not free from limitations, particularly related to the two-time period setting, which does not allow to fully rule out endogeneity concerns deriving from the likely bidirectional link between academic engagement and research quality, as well as experience. More generally, given the focus on one specific channel of U-I interaction, namely formalised joint research partnerships, our findings may not be easily extended to other channels – most notably the less formalised ones. Yet, it is worth underlining that U-I research collaborations are extremely widespread in many advanced countries and represent one of the most used policy tools to support U-I knowledge transfer in the economy.

Notwithstanding, this work provides interesting associations between academic engagement and the quality of academic research as well as the level of experience, hence contributing to the innovation literature on U-I linkages. Firstly, we show the importance of analysing the joint effect of various determinants of academic engagement, in line with studies suggesting that factors like research quality do not unambiguously affect any form of academia-industry interaction (D'Este and Iammarino, 2010). Our findings highlight that the so-called *disciplinary-effects* are intertwined with other determinants, such as the extent of experience and research quality. While past research does suggest that these factors may be interdependent (see e.g. Olmos-Penuela et al., 2014), both the links between scientific disciplines and experience, and between scientific disciplines and research quality, were underexplored in the literature. Secondly, our work underscores that some of the key dynamics behind university-industry interactions take place within academic departments. While the role of individual-level factors determining academic engagement is well explored in the literature, our analysis emphasizes that department research standing and experience in academic engagement play a major role in influencing the extent of companies' involvement into research collaboration, hence pointing to the relevance of collective research efforts and local culture.

This research also highlights some key factors that policy makers should take into account when dealing with policy initiatives aimed at supporting U-I interactions. In the first place, differences between academic disciplines in the patterns of academic engagement should be accounted for by policy makers and universities. Strategies and policies promoting academic engagement should hence be adapted to such differences so to maximise the expected outcomes. Second, a negative relationship between research quality and university engagement with industry (in the basic sciences) may result in the *adverse selection* of academic institutions into cooperation with businesses. Accordingly, lower quality institutions sort into collaborating with firms and, it follows, firms get access to lower quality research. This could be potentially detrimental to the value of academic engagement for firms and for the society more generally. Yet, it should be noted that researchers within low quality institutions often seek industry collaboration in order to acquire research funds that lack precisely because of the low quality level (Perkmann et al., 2013). Therefore, policy makers need acknowledge the possibility of adverse selection and consider whether it is a desirable outcome for the university system as well as for the whole economy. If not, appropriate measures aimed at counterbalancing such effect should be put in place, including the specific targeting of low quality institutions with the aim of both improving their research standing and providing additional funding for U-I interactions. Finally, and relatedly, our empirical finding about the interaction effect of research quality and experience for academic engagement provides a key insight for universities and policy makers. We have shown that cumulated experience in U-I interaction appears to mitigate the negative relationship between research quality and academic engagement in basic-sciences departments, hence influencing the extent of future interactions. Therefore, it is arguable that academia-business linkages not only have direct positive effects on public and private research, but they also have indirect effects because they are likely to boost future interactions. Both policy makers and technology transfer managers inside universities should take such indirect effect into account, as it may represent an additional reason for supporting low quality institutions to avoid adverse selection effects.

References

Abramovsky, L., R. Harrison, and H. Simpson (2007). University research and the location of business R&D. *The Economic Journal 117*(519), C114– C141.

Aghion, P., M. Dewatripont, and L. C. Stein (2008). Academic freedom, private-sector focus, and the process of innovation. *The RAND Journal of Economics* 39, no. 3: 617-635.

Ambos, T. C., K. Mäkelä, J. Birkinshaw, and P. D'Este (2008). When does university research get commercialized? Creating ambidexterity in research institutions. *Journal of Management Studies 45*(8), 1424–1447.

Angrist, J. D. and J.-S. Pischke (2008). *Mostly harmless econometrics: An empiricist's companion*. Princeton university press.

Antonioli, D., Marzucchi, A., and M. Savona (2017). Pain shared, pain halved? Cooperation as a coping strategy for innovation barriers. *The Journal of Technology Transfer*, *42*(4), 841-864.

Archibugi, D., & Filippetti, A. (2018). The retreat of public research and its adverse consequences on innovation. *Technological Forecasting and Social Change*, *127*, 97-111.

Audretsch, D. B. and M. P. Feldman (1996). R&D spillovers and the geography of innovation and production. *The American Economic Review*, 630– 640.

Audretsch, D. B. and E. E. Lehmann (2005). Does the knowledge spillover theory of entrepreneurship hold for regions? *Research Policy 34*(8), 1191– 1202.

Barker, K. (2007). The UK Research Assessment Exercise: the evolution of a national research evaluation system. *Research Evaluation 16*(1), 3–12.

Bekkers, R. and I. M. Bodas Freitas (2008). Analysing knowledge transfer channels between universities and industry: To what degree do sectors also matter? *Research Policy 37*(10), 1837–1853.

Bercovitz, J., and M. Feldman (2006). Entrepreneurial universities and technology transfer: A conceptual framework for understanding knowledge-based economic development. *The Journal of Technology Transfer*, *31*, 175–188.

Bishop, K., P. D'Este, and A. Neely (2011). Gaining from interactions with universities: Multiple methods for nurturing absorptive capacity. *Research Policy* 40, no. 1: 30-40.

Boardman, P. and B. L. Ponomariov (2009). University researchers working with private companies. *Technovation 29*(2), 142–153.

Boardman, P. C. (2009). Government centrality to university–industry interactions: University research centers and the industry involvement of academic researchers. *Research Policy 38*(10), 1505–1516.

Bozeman, B. and M. Gaughan (2007). Impacts of grants and contracts on academic researchers' interactions with industry. *Research Policy 36*(5), 694–707.

Bozeman, B., Rimes, H., Youtie, J. (2015). The evolving state-of-the-art in technology transfer research: revisiting the contingent effectiveness model. *Research Policy* 44 (1), 34–49.

Burbidge, J. B., L. Magee, and A. L. Robb (1988). Alternative transformations to handle extreme values of the dependent variable. *Journal of the American Statistical Association* 83, no. 401: 123-127.

Crane, D. (1972). Invisible colleges; diffusion of knowledge in scientific communities. University of Chicago Press.

Crescenzi, R., Filippetti, A., and S. Iammarino (2017). Academic inventors: Collaboration and proximity with industry. *The Journal of Technology Transfer*, 42, 730–762.

Dasgupta, P. and P. A. David (1994). Toward a new economics of science. *Research Policy* 23, 5: 487-521.

D'Este, P. and R. Fontana (2007). What drives the emergence of entrepreneurial academics? A study on collaborative research partnerships in the UK. *Research Evaluation 16*(4), 257–270.

D'Este, P., F. Guy, and S. Iammarino (2013). Shaping the formation of university–industry research collaborations: what type of proximity does really matter? *Journal of Economic Geography*, *13*(4), 537-558.

D'Este, P. and S. Iammarino (2010). The spatial profile of university-business research partnerships. *Papers in regional science, 89*(2), 335–350.

D'Este, P. and P. Patel (2007). University–industry linkages in the UK: What are the factors underlying the variety of interactions with industry? *Research Policy 36*(9), 1295–1313.

D'Este, P. and M. Perkmann (2011). Why do academics engage with industry? The entrepreneurial university and individual motivations. *The Journal of Technology Transfer, 36*(3), 316–339.

Etzkowitz, H., A. Webster, C. Gebhardt, and B. R. C. Terra (2000). The future of the university and the university of the future: evolution of ivory tower to entrepreneurial paradigm. *Research Policy 29*(2), 313–330.

Feller, I., and D. Roessner (1995). What does industry expect from university partnerships?. *Issues in Science and Technology* 12, no. 1: 80-84.

Filippetti, A., and M. Savona (2017). University–industry linkages and academic engagements: individual behaviours and firms' barriers. Introduction to the special section. *The Journal of Technology Transfer*, 42, 719–729.

Fisher, R., W. Polt, and N. Vonortas (2009). The impact of publicly funded research on innovation: An analysis of European Framework Programmes for research and development. *INNO Europe paper N7, European Commission Enterprise and Industry*.

Fontana, R., A. Geuna, and M. Matt (2006). Factors affecting university– industry R&D projects: The importance of searching, screening and signalling. *Research Policy 35*(2), 309–323.

Freitas, I. M. B., A. Geuna, and F. Rossi (2011). University–industry inter- actions: the unresolved puzzle. *Handbook on the Economic Complexity of Technological Change*, 262.

Geuna, A. and A. Muscio (2009). The governance of university knowledge transfer: A critical review of the literature. *Minerva 47*(1), 93–114.

Geuna, A. and Rossi, F. (2013). *L'università e il sistema economico: conoscenza, progresso tecnologico* *e crescita*. Il Mulino, Bologna.

Giuri, P., F. Munari, A. Scandura, and L. Toschi (2019). The strategic orientation of universities in knowledge transfer activities. *Technological Forecasting and Social Change* 138: 261-278.

Gulbrandsen, M. and J.-C. Smeby (2005). Industry funding and university professors' research performance. *Research Policy 34*(6), 932–950.

Haeussler, C. and J. A. Colyvas (2011). Breaking the ivory tower: academic entrepreneurship in the life sciences in UK and Germany. *Research Policy 40*(1), 41–54.

Henderson, J. V. (2007). Understanding knowledge spillovers. *Regional Science and Urban Economics 37*(4), 497–508.

Hsu, D.W.L., Shen, Y-C, Yuan B.J.C. and 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.

Jaffe, A. B. (1989). Real effects of academic research. *The American Economic Review*, 957–970.

Johnson, Norman L. (1949). Systems of frequency curves generated by methods of translation. *Biometrika* 36, no. 1/2 (1949): 149-176.

Kochenkova, A., Grimaldi, R., & Munari, F. (2016). Public policy measures in support of knowledge transfer activities: a review of academic literature. *The Journal of Technology Transfer*, *41*(3), 407-429.

Laursen, K., T. Reichstein, and A. Salter (2011). Exploring the effect of geo- graphical proximity and university quality on university–industry collaboration in the United Kingdom. *Regional Studies 45*(4), 507–523.

Lawton Smith, H. and S. Bagchi-Sen (2006). University–industry interactions: the case of the UK biotech industry. *Industry and Innovation 13*(4), 371–392.

Lawton Smith, H. and S. Bagchi-Sen (2012). The research university, entrepreneurship and regional development: Research propositions and cur- rent evidence. *Entrepreneurship & Regional Development 24*(5-6), 383–404.

Lee, S. and B. Bozeman (2005). The impact of research collaboration on scientific productivity. *Social studies of science 35*(5), 673–702.

Link, A. N., D. S. Siegel, and B. Bozeman (2007). An empirical analysis of the propensity of academics to engage in informal university technology transfer. *Industrial and Corporate Change 16*(4), 641–655.

MacKinnon, J. G., and L. Magee (1990). Transforming the dependent variable in regression models. *International Economic Review*: 315-339.

Mansfield, E. (1995). Academic research underlying industrial innovations: sources, characteristics, and financing. *The review of Economics and Statistics*, 55–65.

Mansfield, E. (1997). Academic research and industrial innovation: An up- date of empirical findings. *Research Policy 26*(7), 773–776.

Mansfield, E. and J. Lee (1996). The modern university: contributor to industrial innovation and recipient of industrial R&D support. *Research Policy 25*(7), 1047–1058.

Martin, S., and J. T. Scott (2000). The nature of innovation market failure and the design of public support for private innovation. *Research Policy* 29, no. 4-5: 437-447.

Martinelli, A., M. Meyer, and N. Von Tunzelmann (2008). Becoming an entrepreneurial university? A case study of knowledge exchange relationships and faculty attitudes in a medium-sized, research-oriented university. *The Journal of Technology Transfer* 33, no. 3: 259-283.

Meyer-Krahmer, F., and U. Schmoch (1998). Science-based technologies: university–industry interactions in four fields. *Research Policy* 27, no. 8: 835-851.

McGuinness, S. (2003). University quality and labour market outcomes. *Applied Economics 35*(18), 1943–1955.

Merton, R. K. (1968). The Matthew effect in science. *Science 159*(3810), 56–63.

O'Shea, R. P., Chugh, H., & Allen, T. J. (2008). Determinants and consequences of university spinoff activity: a conceptual framework. *The Journal of Technology Transfer*, *33*(6), 653-666.

OECD (1998). *STI Policy Review No. 23 Special Issue on Public/Private Partnerships in Science and Technology*. Paris.

OECD (2002). *Benchmarking industry-science relationships*. Paris.

Olmos-Peñuela, J., E. Castro-Martínez, and P. D'Este (2014). Knowledge transfer activities in social sciences and humanities: Explaining the interactions of research groups with non-academic agents. *Research Policy* 43, no. 4: 696-706.

Perkmann, M., Z. King, and S. Pavelin (2011). Engaging excellence? Effects of faculty quality on university engagement with industry. *Research Policy 40*(4), 539–552.

Perkmann, M., V. Tartari, M. McKelvey, E. Autio, A. Broström, P. D'Este, R. Fini, A. Geuna, R. Grimaldi, A. Hughes, S. Krabel, M. Kitson, P. Llerena, F. Lissoni, A. Salter, and M. Sobrero (2013). Academic engagement and commercialisation: A review of the literature on university–industry relations. *Research Policy 42*(2), 423–442.

Phan, P. H., & Siegel, D. S. (2006). The effectiveness of university technology transfer. *Foundations and Trends® in Entrepreneurship*, *2*(2), 77-144.

Ponomariov, B. (2008). Effects of university characteristics on scientists' interactions with the private sector: An exploratory assessment. *The Journal of Technology Transfer 33*(5), 485–503.

Rossi, F. and A. Rosli (2013). Indicators of university-industry knowledge transfer performance and their implications for universities: evidence from the UK's HE-BCI survey. *CIMR Research Working Paper Series WP No. 13*.

Rothaermel, F. T., Agung, S. D., & Jiang, L. (2007). University entrepreneurship: a taxonomy of the literature. *Industrial and corporate change*, *16*(4), 691-791.

Scandura, A. (2016). University–industry collaboration and firms' R&D effort. *Research Policy* 45, no. 9 (2016): 1907-1922.

Schartinger, D., C. Rammer, M. Fischer, and J. Frö hlich (2002). Knowledge interactions between universities and industry in Austria: sectoral patterns and determinants. *Research Policy 31*(3), 303–328.

Tornquist, K. M. and L. A. Kallsen (1994). Out of the ivory tower: Characteristics of institutions meeting the research needs of industry. *The Journal of Higher Education*, 523–539.

Trune, D.R., and Goslin, L.N. (1998). University Technology Transfer Programs: A Profit/Loss Analysis. *Technological Forecasting and Social Change*, 57(3), 197-204.

Van Dierdonck, R., K. Debackere, and B. Engelen (1990). University-industry relationships: How does the Belgian academic community feel about it? *Research Policy 19*(6), 551–566.

Varga, A. (2000). Local academic knowledge transfers and the concentration of economic activity. *Journal of Regional Science 40*(2), 289–309.

Table 1 Variable list (N=280)

Variable	Description (Source)	Mean	Std. Dev.	Min	Max
Dep. Var.					
IndFund	Funding from companies for EPSRC collaborations in 2001-2007 (EPSRC)	1517703	2688188	0	1.5e+07
Indep. Vars.					
TopQual	0/1 dummy indicating departments of high/very high research quality (own elaboration from RAE 2001)	0.5250	0.5003	0	1
QualLevel_1	0/1 dummy indicating departments of medium research quality (own elaboration from RAE 2001)	0.4750	0.5002	0	1
QualLevel_2	0/1 dummy indicating departments of high research quality (own elaboration from RAE 2001)	0.3857	0.4876	0	1
QualLevel_3	0/1 dummy indicating departments of very high research quality (own elaboration from RAE 2001)	0.1393	0.3469	0	1
Basic	0/1 dummy indicating departments of basic sciences (own elaboration from RAE 2001)	0.3285	0.4705	0	1
Applied	0/1 dummy indicating departments of applied sciences (own elaboration from RAE 2001)	0.5964	0.4914	0	1
Other	0/1 dummy indicating departments of other disciplines (own elaboration from RAE 2001)	0.075	0.2338	0	1
Experience	Funding from EPSRC for U-I collaboration in 1992-2000 (EPSRC)	2043875	2851427	19959.7	2.4e+07
Control Vars.					
TotIndFund	Total funding from private sources in 1992-2000 (RAE 2001)	1122886	1812440	0	1.37e+07
PublFund	Total funding from public sources that from EPSRC for U-I collaboration (RAE 2001)	1135152	2871275	0	4.48e+07
Size	count of research active staff at time of RAE submission (RAE 2001)	28.1571	22.6606	1	167
Dist	mean distance (in Km) between universities and collaborating firms in 1992-2000 (own elaboration)	192.9427	115.6085	0	596.1332
Eastmid	0/1 dummy indicating departments located in East Midlands	0.0821	0.2751	0	1
Easteng	0/1 dummy indicating departments located in East of England	0.0536	0.2256	0	1
London	0/1 dummy indicating departments located in London	0.1464	0.3542	0	1
Noreast	0/1 dummy indicating departments located in North East	0.0393	0.1946	0	1
Norwes	0/1 dummy indicating departments located in North West	0.0821	0.2751	0	1
Noirela	0/1 dummy indicating departments located in Northern Ireland	0.0250	0.1564	0	1
Scotlan	0/1 dummy indicating departments located in Scotland	0.1393	0.3469	0	1
Southea	0/1 dummy indicating departments located in South East	0.1214	0.3272	0	1
Southwe	0/1 dummy indicating departments located in South West	0.0786	0.2696	0	1
Wales	0/1 dummy indicating departments located in Wales	0.0536	0.2256	0	1
Westmid	0/1 dummy indicating departments located in West Midlands	0.0714	0.2580	0	1
Yorkhum	0/1 dummy indicating departments located in Yorkshire and the Humber	0.1071	0.3098	0	1

Table 2 Independent variable: quality profiles of academic departments (N=280)

Rating RAE 2001	Freq.	%	Cum.	*QualLevel_*
2	1	0.36	0.36	1
3a	36	12.86	13.21	1
3b	14	5.00	18.21	1
4	82	29.29	47.50	1
5	108	38.57	86.07	2
5*	39	13.93	100.00	3
Total	280	100.00		

Table 3 Independent variable: scientific disciplines of academic departments (N=280)

Dept. scientific area	Freq.	%	Cum.
Applied	167	59.64	59.64
Basic	92	32.86	92.50
Other	21	7.50	100.00
Total	280	100.00	

Table 4 Independent variables: quality levels and scientific disciplines of academic departments (N=280).

	Full sample (%)	*Basic* (%)	*Applied* (%)
QualLevel_1	47.5	33.7	50.9
QualLevel_2	38.57	48.91	35.33
QualLevel_3	13.93	17.39	13.77

Table 5 Independent variables: experience in U-I collaboration across quality levels and scientific disciplines of academic departments (N=280)

	Experience across quality levels		
	Mean (mln GBP)	Std. Dev. (mln GBP)	Freq.
QualLevel_1	1157899.4	1699070.7	133
QualLevel_2	2061063.6	2168080.3	108
QualLevel_3	5017683.2	4960621.8	39
	Experience across disciplines		
	Mean (mln GBP)	Std. Dev. (mln GBP)	Freq.
Applied	2301339.4	3242856	167
Basic	1847308	2226634.8	92

Table 6 OLS regressions Hp 1a and 1b. Dep. Var.: *IndFund*

VARIABLES	(1) Full sample *IndFund*	(2) Full sample *IndFund*	(3) Full sample *IndFund*	(4) Full sample *IndFund*
TopQual	0.624*	-0.615		
	(0.322)	(0.421)		
QualLevel_2			0.582*	-0.633
			(0.325)	(0.449)
QualLevel_3			0.873**	-0.430
			(0.417)	(0.487)
Basic	1.013*	0.792	1.015*	0.794
	(0.562)	(0.520)	(0.564)	(0.523)
Applied	0.498	0.210	0.492	0.211
	(0.520)	(0.540)	(0.520)	(0.543)
*TopQual*Basic*	-1.228**			
	(0.510)			
*TopQual*Applied*		1.349***		
		(0.500)		
*QualLevel_2*Basic*			-1.202**	
			(0.556)	
*QualLevel_3*Basic*			-1.299**	
			(0.557)	
*QualLevel_2*Applied*				1.335**
				(0.539)
*QualLevel_3*Applied*				1.348**
				(0.554)
Experience	0.729***	0.739***	0.715***	0.728***
	(0.119)	(0.117)	(0.124)	(0.122)
TotIndFund	0.101*	0.100*	0.101	0.0996
	(0.0612)	(0.0606)	(0.0612)	(0.0606)
PublFund	0.0154	0.0172	0.0181	0.0194
	(0.0437)	(0.0431)	(0.0435)	(0.0431)
Size	0.392	0.374	0.361	0.346
	(0.258)	(0.254)	(0.261)	(0.258)
Dist	-0.174	-0.181	-0.166	-0.174
	(0.159)	(0.158)	(0.161)	(0.160)
Eastmid	0.724	0.776	0.758	0.806
	(0.567)	(0.567)	(0.579)	(0.580)
Easteng	0.636	0.662	0.620	0.647
	(0.470)	(0.468)	(0.467)	(0.466)
Noreast	0.499	0.522	0.531	0.544
	(0.617)	(0.615)	(0.621)	(0.618)
Norwest	0.504	0.517	0.524	0.533
	(0.536)	(0.535)	(0.539)	(0.538)
Noirela	0.966*	0.964*	1.002*	0.996*
	(0.539)	(0.545)	(0.550)	(0.556)
Scotlan	0.171	0.213	0.202	0.242
	(0.501)	(0.501)	(0.508)	(0.509)
Southea	0.180	0.182	0.165	0.173
	(0.615)	(0.612)	(0.620)	(0.618)
Southwe	0.855*	0.920*	0.859*	0.923*

	(0.502)	(0.515)	(0.505)	(0.519)
Wales	0.477	0.485	0.503	0.510
	(0.688)	(0.680)	(0.693)	(0.686)
Westmid	0.826*	0.821*	0.841*	0.836*
	(0.496)	(0.494)	(0.500)	(0.498)
Yorkhum	0.454	0.472	0.458	0.481
	(0.475)	(0.466)	(0.481)	(0.471)
Constant	-0.274	-0.0956	-0.0500	0.0754
	(1.390)	(1.389)	(1.446)	(1.444)
Observations	280	280	280	280
R-squared	0.380	0.384	0.381	0.385
Adj R-squared	0.332	0.336	0.328	0.332
F	9.182	9.485	12.18	12.22
Prob>F	0	0	0	0
LogLikelihood	-577.1	-576.2	-576.9	-576.1
LogLikelihood costant-only model	-644.1	-644.1	-644.1	-644.1

Robust standard errors in parentheses (*** p<0.01, ** p<0.05, * p<0.1).
QualLevel_1, *Other* and *London* omitted because of collinearity.

Table 7 OLS regressions Hp 2a and 2b. Dep. Var.: IndFund

VARIABLES	(1) Basic sciences *IndFund*	(2) Applied sciences *IndFund*	(3) Basic sciences *IndFund*	(4) Applied sciences *IndFund*
TopQual	-13.34***	-1.971		
	(4.741)	(2.955)		
QualLevel_2			-14.52***	-1.262
			(5.405)	(3.572)
QualLevel_3			-11.29**	-1.815
			(5.310)	(4.495)
Experience	0.320	0.540***	0.318	0.543***
	(0.292)	(0.199)	(0.295)	(0.200)
*TopQual*Experience*	0.881***	0.191		
	(0.321)	(0.198)		
*QualLevel_2*Experience*			0.964**	0.140
			(0.366)	(0.241)
*QualLevel_3*Experience*			0.721**	0.191
			(0.356)	(0.288)
TotIndFund	0.120	0.0815	0.124	0.0826
	(0.106)	(0.0849)	(0.109)	(0.0860)
PublFund	0.0663	-0.00286	0.0574	-0.000994
	(0.0982)	(0.0511)	(0.0975)	(0.0513)
Size	0.127	0.485	0.187	0.465
	(0.290)	(0.450)	(0.284)	(0.445)
Dist	-0.523**	0.231	-0.543**	0.234
	(0.217)	(0.316)	(0.227)	(0.319)
Eastmid	-0.407	1.695**	-0.608	1.716**
	(0.766)	(0.764)	(0.906)	(0.769)
Easteng	0.208	0.765	0.249	0.744
	(0.875)	(0.671)	(0.878)	(0.685)
Noreast	0.441	0.214	0.415	0.236
	(1.054)	(0.753)	(1.280)	(0.767)
Norwest	0.647	-0.0245	0.527	-0.0172
	(0.868)	(0.674)	(0.934)	(0.680)
Noirela	2.242***	0.0172	2.053***	0.0430
	(0.648)	(0.731)	(0.774)	(0.746)
Scotlan	0.776	-0.270	0.634	-0.258
	(1.038)	(0.639)	(1.142)	(0.651)
Southea	0.315	-0.199	0.277	-0.235
	(0.646)	(0.974)	(0.686)	(1.017)
Southwe	0.831	0.712	0.750	0.704
	(0.858)	(0.647)	(0.909)	(0.653)
Wales	-0.835	0.434	-1.014	0.436
	(1.403)	(0.831)	(1.501)	(0.839)
Westmid	-0.227	0.961	-0.470	0.952
	(1.009)	(0.630)	(1.144)	(0.631)
Yorkhum	-0.00225	0.584	-0.188	0.557
	(1.017)	(0.540)	(1.123)	(0.544)
Constant	8.917**	0.759	9.029**	0.731
	(4.068)	(3.017)	(4.112)	(3.034)

Observations	92	167	92	167
R-squared	0.532	0.403	0.535	0.404
Adj R-squared	0.417	0.331	0.405	0.322
F	9.768	11.91	10.58	15.26
Prob>F	0	0	0	0
LogLikelihood	-180.9	-338.5	-180.6	-338.4
LogLikelihood costant-only model	-215.8	-381.6	-215.8	-381.6

Robust standard errors in parentheses (*** p<0.01, ** p<0.05, * p<0.1).
QualLevel_1 and *London* omitted because of collinearity.

Table 8 Robustness check: OLS regressions Hp 1a and 1b. Dep. Var.: *IndFundGrant*

VARIABLES	(1) Full sample *IndFundGrant*	(2) Full sample *IndFundGrant*	(3) Full sample *IndFundGrant*	(4) Full sample *IndFundGrant*
TopQual	0.322	-0.726**		
	(0.262)	(0.368)		
QualLevel_2			0.292	-0.772*
			(0.254)	(0.400)
QualLevel_3			0.527	-0.362
			(0.370)	(0.354)
Basic	0.790*	0.580	0.788*	0.567
	(0.465)	(0.401)	(0.463)	(0.407)
Applied	0.185	-0.0905	0.180	-0.0964
	(0.374)	(0.397)	(0.372)	(0.398)
*TopQual*Basic*	-1.033**			
	(0.443)			
*TopQual*Applied*		1.158***		
		(0.418)		
*QualLevel_2*Basic*			-1.051**	
			(0.476)	
*QualLevel_3*Basic*			-0.882*	
			(0.509)	
*QualLevel_2*Applied*				1.184***
				(0.446)
*QualLevel_3*Applied*				0.927*
				(0.499)
Experience	0.0886	0.0944	0.0662	0.0770
	(0.113)	(0.113)	(0.119)	(0.119)
Constant	7.129***	7.344***	7.415***	7.584***
	(1.281)	(1.259)	(1.308)	(1.293)
Control variables	yes	yes	yes	yes
Observations	239	239	239	239
R-squared	0.205	0.212	0.208	0.215
Adj R-squared	0.136	0.144	0.131	0.139
F	2.114	2.389	2.752	2.882
Prob>F	0	0	0	0
LogLikelihood	-430.7	-429.6	-430.3	-429.3
LogLikelihood costant-only model	-458.2	-458.2	-458.2	-458.2

Robust standard errors in parentheses (*** p<0.01, ** p<0.05, * p<0.1)

Table 9 Robustness check: OLS regressions Hp 2a and 2b. Dep. Var.: *IndFundGrant*

	(1)	(2)	(3)	(4)
	Basic sciences	Applied sciences	Basic sciences	Applied sciences
VARIABLES	*IndFundGrant*	*IndFundGrant*	*IndFundGrant*	*IndFundGrant*
TopQual	-14.46**	0.138		
	(5.455)	(2.193)		
QualLevel_2			-17.04***	1.372
			(6.312)	(2.379)
QualLevel_3			-3.497	-1.369
			(5.721)	(4.068)
Experience	-0.319	0.112	-0.389	0.103
	(0.344)	(0.186)	(0.364)	(0.191)
*TopQual*Experience*	0.943**	0.0337		
	(0.365)	(0.150)		
*QualLevel_2*Experience*			1.124**	-0.0545
			(0.425)	(0.162)
*QualLevel_3*Experience*			0.220	0.141
			(0.375)	(0.270)
Constant	14.93***	6.832***	15.68***	6.848***
	(4.130)	(2.517)	(4.385)	(2.557)
Control variables	yes	yes	yes	yes
Observations	82	138	82	138
R-squared	0.445	0.236	0.475	0.241
Adj R-squared	0.297	0.128	0.314	0.118
F	4.428	2.851	4.381	2.918
Prob>F	0	0	0	0
LogLikelihood	-146.5	-229.5	-144.1	-229.1
LogLikelihood costant-only model	-170.6	-248.1	-170.6	-248.1

Robust standard errors in parentheses (*** p<0.01, ** p<0.05, * p<0.1)

Table 10 Robustness check: OLS regressions Hp 1a, 1b, 2a, 2b. Quality measure: *TopQualNew*

	(1) Full sample	(2) Full sample	(3) Basic sciences	(4) Applied sciences
VARIABLES	*IndFund*	*IndFund*	*IndFund*	*IndFund*
TopQualNew	0.536	-0.899	-8.760	-0.859
	(0.325)	(0.578)	(5.568)	(3.006)
Basic	1.254**	0.371		
	(0.567)	(0.603)		
Applied	0.881*	-0.146		
	(0.527)	(0.625)		
Experience	0.731***	0.721***	0.806***	0.526**
	(0.125)	(0.123)	(0.243)	(0.234)
*TopQualNew*Basic*	-1.352**			
	(0.677)			
*TopQualNew*Applied*		1.648***		
		(0.598)		
*TopQualNew*Experience*			0.536	0.113
			(0.365)	(0.207)
Constant	0.507	1.459	3.242	2.048
	(1.262)	(1.240)	(2.898)	(2.756)
Control variables	yes	yes	yes	yes
Observations	239	239	82	138
R-squared	0.389	0.399	0.500	0.449
Adj. R-squared	0.336	0.347	0.367	0.371
F	9.224	9.700	6.360	11.63
Prob>F	0	0	0	0
LogLikelihood	-479.9	-477.9	-163.8	-261.7
LogLikelihood costant-only model	-538.8	-538.8	-192.2	-302.9

Robust standard errors in parentheses (*** p<0.01, ** p<0.05, * p<0.1)

Appendix A

Table 11 Pairwise correlations among variables (*5% significance level) (N=280).

	IndFund	*TopQual*	*QualLevel_1*	*QualLevel_2*	*QualLevel_3*	*Basic*	*Applied*	*Experience*	*TotIndFund*	*PublFund*	*Size*	*Dist*	*Eastmid*	*Easteng*	*London*	*Noreast*	*Norwes*	*Noirela*	*Scotlan*	*Southea*	*Southwe*	*Wales*	*Westmid*	*Yorkhum*
IndFund	1																							
TopQual	0.2266*	1																						
QualLevel_1	-0.2266*	-1	1																					
QualLevel_2	0.0889	0.7537*	-0.7537*	1																				
QualLevel_3	0.2018*	0.3826*	-0.3826*	-0.3188*	1																			
Basic	0.0209	0.1934*	-0.1934*	0.1486*	0.07	1																		
Applied	0.0537	-0.0827	0.0827	-0.081	-0.0055	-0.8504*	1																	
Experience	0.5853*	0.2961*	-0.2961*	0.0048	0.4203*	-0.0483	0.11	1																
TotIndFund	0.2383*	0.0484	-0.0484	-0.0407	0.1270*	-0.1712*	0.1783*	0.3075*	1															
PublFund	0.0558	0.0988	-0.0988	0.067	0.0484	0.0597	-0.0488	0.1124	0.101	1														
Size	0.3756*	0.3528*	-0.3528*	0.0023	0.5056*	0.2704*	-0.1964*	0.5537*	0.2791*	0.2012*	1													
Dist	-0.0043	-0.0815	0.0815	0.0538	-0.1932*	0.0312	-0.0346	-0.0633	0.0191	-0.022	-0.112	1												
Eastmid	0.0131	-0.1061	0.1061	-0.0233	-0.1203*	-0.0431	0.0075	-0.0394	0.0592	-0.0358	-0.0809	-0.1699*	1											
Easteng	0.1688*	0.0357	-0.0357	-0.0908	0.1791*	0.0024	0.0341	0.2244*	0.1386*	0.1221*	0.3447*	-0.1187*	-0.0712	1										
London	-0.0233	0.0905	-0.0905	0.0246	0.096	-0.0747	0.0936	-0.0184	-0.0255	0.1297*	-0.0248	-0.2242*	-0.1239*	-0.0985	1									
Noreast	0.0244	0.0083	-0.0083	0.0286	-0.0283	-0.0632	0.0914	0.024	0.079	0.0007	-0.0307	0.1467*	-0.0605	-0.0481	-0.0838	1								
Norwes	-0.0615	-0.054	0.054	0.0034	-0.0828	0.0123	0.0075	-0.0394	-0.0575	-0.0341	-0.1228*	0.0165	-0.0895	-0.0712	-0.1239*	-0.0605	1							
Noirela	-0.0212	-0.0309	0.0309	0.0141	-0.0644	-0.0146	-0.0082	-0.0552	0.0423	-0.0089	0.009	0.2531*	-0.0479	-0.0381	-0.0663	-0.0324	-0.0479	1						
Scotlan	0.0304	-0.0718	0.0718	0.0415	-0.1618*	0.048	-0.0686	-0.0366	-0.0747	-0.0235	-0.0484	0.6808*	-0.1203*	-0.0957	-0.1666*	-0.0813	-0.1203*	-0.0644	1					
Southea	0.0098	0.069	-0.069	-0.0475	0.1662*	0.0426	-0.0285	0.1135	-0.0711	-0.0507	0.1830*	-0.2319*	-0.1112	-0.0884	-0.1540*	-0.0752	-0.1112	-0.0595	-0.1496*	1				
Southwe	-0.0818	-0.0412	0.0412	-0.0405	-0.0025	0.0218	-0.0303	-0.077	-0.0072	-0.0235	-0.0519	-0.0617	-0.0874	-0.0695	-0.1209*	-0.0591	-0.0874	-0.0468	-0.1175*	-0.1086	1			
Wales	-0.0531	-0.0596	0.0596	-0.0256	-0.0499	0.0024	0.0017	-0.0794	-0.1248*	-0.0458	-0.0823	-0.0124	-0.0712	-0.0566	-0.0985	-0.0481	-0.0712	-0.0381	-0.0957	-0.0884	-0.0695	1		
Westmid	0.0178	0.0417	-0.0417	0.0366	0.0086	0.0422	-0.0262	-0.0014	0.0361	-0.0067	-0.0166	-0.2119*	-0.083	-0.066	-0.1149	-0.0561	-0.083	-0.0444	-0.1116	-0.1031	-0.081	-0.066	1	
Yorkhum	-0.0072	0.0751	-0.0751	0.0576	0.0274	0.0035	-0.0446	-0.0124	0.0817	-0.0319	-0.0473	-0.0192	-0.1036	-0.0824	-0.1435*	-0.0701	-0.1036	-0.0555	-0.1394*	-0.1288*	-0.1012	-0.0824	-0.0961	1

Table 12 OLS regressions Hp 1a and 1b, excluding academic departments in London area. Dep. Var.: IndFund.

VARIABLES	(1) *IndFund*	(2) *IndFund*	(3) *IndFund*	(4) *IndFund*
TopQual	0.691**	-0.568		
	(0.311)	(0.451)		
QualLevel_2			0.617**	-0.532
			(0.309)	(0.480)
QualLevel_3			1.029**	-0.631
			(0.448)	(0.542)
Basic	1.271**	1.003*	1.258**	1.014*
	(0.594)	(0.552)	(0.596)	(0.556)
Applied	0.691	0.371	0.668	0.375
	(0.547)	(0.579)	(0.548)	(0.582)
*TopQual*Basic*	-1.277**			
	(0.549)			
*TopQual*Applied*		1.373**		
		(0.535)		
*QualLevel_2*Basic*			-1.159*	
			(0.591)	
*QualLevel_3*Basic*			-1.666***	
			(0.637)	
*QualLevel_2*Applied*				1.268**
				(0.570)
*QualLevel_3*Applied*				1.700***
				(0.634)
Experience	0.679***	0.690***	0.660***	0.674***
	(0.129)	(0.127)	(0.138)	(0.136)
TotIndFund	0.0954	0.0960	0.0952	0.0959
	(0.0698)	(0.0691)	(0.0698)	(0.0693)
PublFund	0.0299	0.0317	0.0320	0.0332
	(0.0420)	(0.0414)	(0.0417)	(0.0412)
Size	0.323	0.297	0.315	0.295
	(0.283)	(0.279)	(0.285)	(0.282)
Dist	-0.184	-0.194	-0.177	-0.188
	(0.164)	(0.163)	(0.167)	(0.166)
Eastmid	0.234	0.271	0.286	0.311
	(0.514)	(0.509)	(0.532)	(0.524)
Easteng	0.216	0.230	0.230	0.243
	(0.414)	(0.407)	(0.415)	(0.407)
Noreast	0.0380	0.0459	0.120	0.115
	(0.583)	(0.575)	(0.605)	(0.594)
Norwest	-0.0175	-0.0164	0.0355	0.0279
	(0.502)	(0.493)	(0.512)	(0.503)
Noirela	0.500	0.486	0.547	0.525
	(0.500)	(0.499)	(0.502)	(0.500)
Scotlan	-0.298	-0.266	-0.256	-0.234
	(0.473)	(0.468)	(0.486)	(0.479)
Southea	-0.296	-0.306	-0.295	-0.303

	(0.571)	(0.563)	(0.574)	(0.566)
Southwe	0.356	0.408	0.391	0.435
	(0.444)	(0.453)	(0.440)	(0.447)
Wales	0.0172	0.0168	0.0537	0.0467
	(0.688)	(0.673)	(0.694)	(0.680)
Westmid	0.327	0.306	0.355	0.331
	(0.452)	(0.442)	(0.458)	(0.449)
Constant	0.922	1.136	1.130	1.284
	(1.343)	(1.345)	(1.406)	(1.406)
Observations	239	239	239	239
R-squared	0.393	0.397	0.395	0.398
Adj R-squared	0.340	0.344	0.336	0.339
F	8.627	9.077	12.67	12.58
Prob>F	0	0	0	0
LogLikelihood	-479.2	-478.5	-478.9	-478.2
LogLikelihood costant-only model	-538.8	-538.8	-538.8	-538.8

Robust standard errors in parentheses (*** p<0.01, ** p<0.05, * p<0.1).
QualLevel_1 and *Yorkhum* omitted because of collinearity.

Table 13 OLS regressions Hp 2a and 2b, excluding academic departments in London area. Dep. Var.: IndFund.

VARIABLES	(1) Basic sciences *IndFund*	(2) Applied sciences *IndFund*	(3) Basic sciences *IndFund*	(4) Applied sciences *IndFund*
TopQual	-13.72***	-1.756		
	(5.115)	(2.727)		
QualLevel_2			-14.95***	-0.421
			(5.600)	(3.392)
QualLevel_3			-12.22**	-0.930
			(5.856)	(4.208)
Experience	0.330	0.447**	0.336	0.448**
	(0.318)	(0.219)	(0.320)	(0.220)
*TopQual*Experience*	0.902**	0.184		
	(0.344)	(0.187)		
*QualLevel_2*Experience*			0.991**	0.0869
			(0.378)	(0.232)
*QualLevel_3*Experience*			0.752*	0.151
			(0.387)	(0.279)
TotIndFund	0.123	0.0848	0.128	0.0875
	(0.118)	(0.0915)	(0.120)	(0.0932)
PublFund	0.108	0.0128	0.0969	0.0146
	(0.109)	(0.0488)	(0.109)	(0.0488)
Size	-0.0383	0.467	0.0670	0.452
	(0.331)	(0.511)	(0.312)	(0.504)
Dist	-0.582**	0.131	-0.620**	0.141
	(0.238)	(0.245)	(0.246)	(0.247)
Eastmid	-0.411	1.023*	-0.426	1.135**
	(0.828)	(0.558)	(0.821)	(0.572)
Easteng	0.243	0.220	0.695	0.226
	(0.993)	(0.453)	(1.047)	(0.487)
Noreast	0.485	-0.291	0.824	-0.181
	(1.133)	(0.667)	(1.497)	(0.704)
Norwest	0.726	-0.641	0.849	-0.555
	(1.084)	(0.538)	(1.116)	(0.557)
Noirela	2.309***	-0.586	2.303***	-0.481
	(0.858)	(0.551)	(0.859)	(0.579)
Scotlan	0.852	-0.797	0.920	-0.713
	(0.984)	(0.484)	(0.991)	(0.513)
Southea	0.405	-0.816	0.664	-0.827
	(0.909)	(0.787)	(0.949)	(0.855)
Southwe	0.820	0.0908	1.043	0.141
	(0.981)	(0.483)	(0.975)	(0.496)
Wales	-0.927	-0.0544	-0.921	0.00253
	(1.415)	(0.741)	(1.440)	(0.753)
Westmid	-0.257	0.312	-0.288	0.357
	(1.035)	(0.428)	(1.052)	(0.429)
Constant	9.201**	3.048	8.942**	2.898
	(4.200)	(2.328)	(4.147)	(2.353)
Observations	82	138	82	138

R-squared	0.524	0.458	0.533	0.462
Adj R-squared	0.397	0.382	0.390	0.375
F	7.571	12.20	8.742	14.74
Prob>F	0	0	0	0
LogLikelihood	-161.8	-260.6	-160.9	-260.1
LogLikelihood costant-only model	-192.2	-302.9	-192.2	-302.9

Robust standard errors in parentheses (*** p<0.01, ** p<0.05, * p<0.1).
QualLevel_1 and *Yorkhum* omitted because of collinearity.