Fishing for Complementarities: Research Grants and Research Productivity

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May 2014

Abstract

We investigate complementarities between different sources of research funding with regard to academic productivity. For a sample of UK engineering academics, we find that public grants are associated with an increase in ex-post publications. The results suggest that the joint effect of public and industry grants depends on the academic's "taste for science" (TFS) and "taste for commercialisation" (TFC). For traditional types with a strong TFS, but low TFC we find that industry funding decreases the marginal utility of public funding by lowering the publication and citation rate increases associated with public grants. For commercial types with high TFC and low TFS, on the contrary, the combined influence of both types of research funding is positive, suggesting complementarities for both publishing and patenting.

Keywords: Research Funding, University-Industry Collaboration, Scientific Productivity

JEL codes: L31; O3

Acknowledgements

We thank Christian Rammer, participants of the Triple Helix Conference, London, and two anonymous referees for helpful comments. Cornelia Lawson acknowledges financial support from the European Commission (FP7) Project #266588, a Collegio Carlo Alberto Project (Researcher Mobility and Scientific Performance) and through a COST-STRIKE Short-Term Scientific Mission Grant.

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1 Introduction

In academic research, external funding is considered crucial for increasing research output (Stephan 1996, 2012) and public research grants have repeatedly been found to positively affect research productivity (Benavente et al., 2012; Chudnovsky et al., 2008; Hottenrott and Thorwarth, 2011; Jacob and Lefgren, 2011; Kelchtermans and Veugelers, 2011). It is important to note, however, that researchers receive grants from several sources. Recent research on the concurrence of different types of funding in selected countries shows that academic publications report an average of two to three funding agents per paper (Wang et al., 2012).

Multiple funding sources facilitate resource-intensive research, and present the challenge of attribution of research efforts and human resources to each project. Importantly, given the significant effects of industry grants on research outcomes (Banal-Estanol et al., 2013; Hottenrott and Thorwarth, 2011), it is of interest whether industry sponsorship accelerates or compromises the positive effect of public research funding. In other words, studying the effects of public funding on research output may require taking other funding channels into account.

Besides the increasing use of external research grants from public funding agents, research sponsorship from the private sector has been identified as an important source of research income, especially by policy makers.[1] Previous work has identified the various forms of interactions with the private sector (e.g. Agrawal and Henderson, 2002; Cohen et al, 2002) and intensively studied the effect of such university-industry interactions on research outcomes (e.g. Blumenthal et al., 1996; Gulbrandsen and Smeby, 2005; Banal-Estanol et al., 2013; Hottenrott and Thorwarth, 2011). It has been claimed that industry partners may direct academics towards applied research and limit or delay the public dissemination of research results (Blumenthal et al., 1996; Cohen et al., 1998; Czarnitzki et al. 2011). These papers conclude that academics' general duties and research activities in particular may be

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[1] In the UK core funding from the funding councils has decreased since 2005. While it provided 72% of income in 2001, it only provided 67% in 2011 (Source: Higher Education Statistical Agency (HESA), own calculation). These recent developments show that external research grant income from public and private sources has become increasingly important for academic researchers. Also, funding from industry increased between 1996 and 2001 by 48% and remained at its 2001 level until 2007. From the HESA data we also see that industry funding is pro-cyclical. It has declined since the crisis year 2008. During our sample period (2001-2007) industry funding accounted for 10% of total research grant income and for 17%-21% of research grant income in engineering sciences. Industry thus presents an important sponsor in the field of engineering which is the focus of this study.

compromised by an increase in time allocated to industry-sponsored research and development, consulting and commercialisation.

If industry partners determine research topics and demand secrecy then public funding placed with such industry sponsored researchers may also suffer from limitations and result in a decrease in research output (Cohen et al., 1998). This is particularly critical in light of a shrinking of institutional core budgets, which increasingly induces researchers to seek out other channels to fund their research. On the other hand, several studies have argued that industry can provide not only funds but also ideas for research (Mansfield, 1995; Lee, 2000; Siegel et al., 2003; Hottenrott and Lawson, 2014). Researchers may be able to benefit in their academic work from closer links with industry, as insights into applied processes and problems in industry may provide the ideas for new ground-breaking research (Rosenberg 1998). If researchers obtain new ideas through links with industry then the expected benefits from public funding placed with these researchers should also increase because of positive complementarities (Mansfield, 1995; Zucker and Darby, 1996; Zucker et al., 1998).

Thus, it is important to note that industry sponsorship cannot be evaluated without considering its impact on productivity effects from other types of funding, which could be positive or negative. The direction of this effect may differ by the type of academic, which may be characterised according to their “taste for science” or “taste for commercialization” (Sauermann and Roach, 2012).

Using the typology that distinguishes between academics with a “taste for science”, “taste for commercialization”, taste for both (“hybrids”) or taste for neither, this study aims to fill this gap. We investigate the joint effect of funding from public and private sponsors on the research productivity of a sample of UK engineering academics. Based on data on research income of 809 individual academics at 15 UK universities we are able to investigate potential complementarities and substitution effects between different sources of private-sector and public-sector funding and how they affect publication and citation rates of the sponsored academics. Previous studies have shown a positive effect of external funding on publication output, but that larger shares of research funding coming from industry are associated with publication rate decreases (Manjarres-Henriquez et al., 2008; Hottenrott and Thorwarth, 2011; Banal-Estanol et al., 2013). Our results add to these insights by showing firstly that external research grants are generally associated with higher research output. The paper also shows that only public funding increases publication and citation rates. Industry funding, instead, decreases the marginal utility of public funding by decreasing the publication and citation rate increase associated with public grants. This effect is most pronounced for traditional academics with a high TFS and is slightly smaller for “hybrid” types. For commercial types, with a strong TFC and weak TFS, we find instead a complementary relationship between public and industry grants on the number of articles published, the average number of citations received and on patenting.

The negative effect of the interaction that we find for a subset of academics does not translate into an effective decrease in publication or citation numbers. Even for very high amounts of industry funding we still observe a positive effect of public funding on publications.

The remainder of the paper is organised as follows: Section 2 summarises the literature on research funding and productivity and section 3 introduces the theoretical model and hypotheses taking into account different research profiles of academics. Section 4 describes the empirical model and methodology, section 5 the data and section 6 presents the results. In section 7 we conclude.

2 Background

2.1 Research funding and research productivity

In many countries in Europe where universities have primarily been financed through block grants, governments have introduced or increased the amount of funding distributed through competitive funding schemes (Stephan, 2012). Additionally, stagnating public research budgets meant that researchers are increasingly encouraged to look for funding elsewhere, e.g. to source funding from industry and other sponsors. External funding has been seen as a mechanism to reward and thus provide incentives for the most able researchers. It allows researchers to secure funding for equipment and research assistance, leading to more autonomy and flexibility. External funding is thus usually accompanied by an increase in research productivity, regardless of the sponsor (Stephan, 2012), and researchers that receive some external funding outperform those who do not acquire external grants (Banal-Estanol et al., 2013; Kelchtermans and Veugelers, 2011).

However, few papers have analysed the concurrence of different types of funding. Wang et al. (2012) analyse named sponsors on academic publications in 10 selected countries. They show for the UK that 43% of academic publications acknowledge external funding and report an average of 2.8 funding agents per paper. They also observe that the UK funding system is particularly diversified, with no one funding agent dominating. In our data we will see that more than 50% of academics receive either competitive public funding or industry funding for at least one year. Of these, 47% receive public grants and industry funding simultaneously at least once. This points to the importance of analysing potential complementary or substitution effects between grants from different funding agents.

2.2 Industry funding and research productivity

Industry grants have been identified as a major source of funding for academic research in recent years. In the US the so called competitiveness crisis prompted a series of structural changes in the intellectual property regime accompanied by several incentive programs designed specifically to promote collaboration between universities and industry (Lee, 2000). Similar incentive schemes were implemented in Europe and elsewhere. In many subject areas, including engineering and material science, much of the research would not be possible without the input of industry partners. In a survey of 671 academic scientists and engineers, Lee (2000) reports securing of funds for equipment and research assistants as the principal reason for collaboration with industry, leading to more autonomy and flexibility for academic researchers. Further, Slaughter and Rhoades (2004) argue that university researchers may be motivated to interact with private companies for reasons other than access to additional research funding, for example finding potential co-authors and ideas for their research agenda. In addition, Lee (2000) identified the acquisition of research ideas as one of the main motives for researchers to pursue joint research with industry. Mansfield (1995) reported that a substantial number of university research projects were initiated through consulting activities with firms. This did not only apply to industry-sponsored projects, also research projects sponsored by public agents were influenced by problems from industry. Thus, industry sponsorship may also increase the marginal benefits associated with public grants, through the provision of additional grants and contact with real-world problems.

However, more than just providing an attractive source of additional research funding to supplement the department’s core resources, external sponsorship involves contractual agreements and research guidance that may potentially affect academic research. Specifically, the objectives of different sponsors may influence the choice of research topics and the choice of dissemination channels (Slaughter and Leslie, 1997; Cohen et al., 1998; Benner and Sandström, 2000), and industry sponsors may have a particular interest in influencing research and dissemination channels to recover their investments. Accordingly, Blumenthal et al. (1996) argue that industry may direct researchers towards applied research and limit or delay the release of publications. Blumenthal et al. (2006) and Czarnitzki et al. (2011) find evidence of publication delay and secrecy associated with industry funding. Such evidence points towards a potential negative effect of industry involvement on publication rates which could further result in a negative effect on marginal benefits associated with simultaneously-received public funding.

Empirical evidence on the topic is mixed. Manjarres-Henriquez et al. (2008) and Banal-Estanol et al. (2013) show a curvilinear effect of the share of industry funding on publication output which may be indicative of a complementary effect of public and private funding up to a certain threshold. Other recent studies instead show a consistent negative correlation between the share of industry grants and publication rates (Hottenrott and Thorwarth, 2011). Hottenrott and Lawson (2014) find researchers that report industry as a source for research ideas to publish less than their peers who source research ideas from elsewhere. Their findings suggest that ideas coming from industry do not translate into more or better quality publications. Thus, the potential negative effect of industry funding may simply be offset through public grants instead of creating true complementarities.

3 Theoretical Framework

The effects of research funding on research productivity as well as the interaction between different types of grants may not exclusively depend on the funding source, but also on the academics who receive these grants. Previous research has studied heterogeneity amongst academics and their "taste" for research. In particular, the term "taste for science" has been coined to describe preferences related to the intrinsic desire to produce and diffuse basic scientific knowledge without considering monetary returns (Stern, 2004; Lacetera and Zirulina, 2008; Agarwal and Ohyama, 2013). Roach and Sauermann (2010) consider academic freedom, peer recognition and collaboration as value creators for academics with a "taste for science" (TFS). Pecuniary incentives are assumed to be of minor importance to these traditional academics, while academics with a "taste for commercialisation" (TFC) may seek to actively commercialise their scientific knowledge. Academics with a TFC may draw fewer rewards from diffusing their insights using traditional scientific means like publications, but rather seek patent protection for their inventions. It has been argued that between these two opposites we may find "hybrid" types (hybrids). These "hybrids" have attracted considerable attention lately (Owen-Smith, 2003; Thursby et al., 2007; Sauermann et al., 2010; Lam, 2011) because of their potential to act as intermediaries between science and industry helping to valorise additional social and economic returns from publicly funded research. Following Sauermann and Roach (2012), we can classify academics according to their tastes across the two-dimensional space as illustrated in Figure 1.

[Figure 1 about here]

In our setting, which looks at engineering academics, we can classify engineers as high in TFS if they publish at least one science-oriented paper[2] during the observation period and high in TFC if they apply for at least one patent during the observation period.

Traditional scientists with a high TFS may be more interested in basic research and if they engage in applied research, it may be without pursuing commercial opportunities. Academics have repeatedly been shown to possess a "taste" for science when deriving satisfaction from "puzzle solving" (Stephan, 1996, 2012; Stern, 2004; Sauermann and Roach, 2014). Such academics may source their utility primarily from publications in peer reviewed journals as publications in peer-reviewed journals in turn provide substantial benefits in terms of career, salary and internal and external recognition (Dasgupta and David, 1994; Stephan, 1996, 2012). In line with previous research, we expect that, controlling for pre-grant research performance, public grants have a positive effect on the productivity of these academics in terms of publications. The effect on publications may be especially strong if grants promote basic research and encourage research collaboration. Likewise, if peer-recognition is a major source of reward for these researchers, they may have incentives to publish their results and do so with highest possible visibility.

Facing time-constraints academics have to choose how much time to devote to each sponsor. It seems reasonable to assume that different types of grants are not frictionless adjustable as they are subject to different adjustment costs and are accompanied by different expectations of the sponsors. If traditional scientists receive industry grants in addition to their public grants, their publication output may be reduced due to several reasons. Contractual arrangements with the sponsor may require delaying or withholding results from publication in scientific journals (Blumenthal et al., 1996; Cohen et al., 1998; Czarnitzki et al. 2011). Earlier research has also found that funding from industry is less targeted at the production of

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[2] Narin (1976) classified basic and applied type journals based on cross-citation matrices between journals. He distinguishes between four categories where 1 is the most applied and 4 the most basic. We consider a paper to be science-oriented if it falls in categories 3 or 4. See section 5.3 for details.

scientific publications and basic research than unrestricted funding from public sponsors (Blumenthal et al., 1996). Funding from industry could thus be considered restricted funding that may potentially adversely affect an academic’s publication behaviour (Cohen et al., 1998). Moreover, academics may encounter conflicting incentives and guidelines in their research when receiving funding from more than one agent. Public funding aimed at free dissemination may be contradicted with industry funding, resulting in a substitution between different grants and a negative effect of industry funding on the marginal benefits associated with public grants.

Moreover, industry-sponsored projects may be related to, but still substantially different from a traditional academic’s other research projects in terms of materials used, methodologies applied or procedures necessary to obtain usable results. When more time is allocated to industry-sponsored research and development, or to consulting, in addition to administrative and teaching duties, traditional research may be compromised. For traditional academics with a high TFS, we would therefore expect a) a negative effect of industry grants on research productivity and b) industry grants to (partially) compromise the output gains related to public grants.

The case for “hybrid” types may be different. With their research focus closer to commercial interests, they may be able to recognise and realise commercial opportunities that are aligned to the traditional research that is conducted in the context of publicly funded research projects. Lam (2011) also shows that researchers involved in patenting are indeed primarily motivated by academic goals, including increased reputation and access to new sources of funding. Contact with an industry sponsor may then help generate new ideas for research (Lee, 2000) and the different grants could be complements in the academic’s production function. Hottenrott (2012) further finds that research units that comprise both basic and applied research focus attract more research funding from industry than more focused ones do. Being a highly attractive collaboration partner for firms may thus put “hybrid” types in an advantageous bargaining position that allows them to achieve sponsoring contracts with fewer strings attached. Research output gains from public grants may therefore be compromised to a lesser extent for “hybrid” types compared to traditional academics with high TFS and low TFC. There may be complementarities to be realised within these researchers’ projects financed from public and industry sources. In this context, previous research has repeatedly stressed the concept of ‘dual knowledge’ and the occurrence of patent-paper pairs (Ducor 2000, Murray 2002, Murray and Stern 2007). Academics produce such pairs when they publish their research results in both scientific journals and in patent applications. For “hybrid” academics with high TFS and high TFC there may be complementarities in industry and public grants with regard to these different research outcomes.

The direct involvement of industry sponsors in the research process as well as the supervision of contract research and the exchange of results may still limit the disclosure of research results or lead to publications that are of lower quality compared to “hybrid” academics that receive funding solely from public sponsors. The expectations regarding the net effect on publications are therefore ambiguous.

For commercial types (TFC) with a relatively low interest in traditional scientific research and/or basic research and dissemination channels, we do not expect public grants to increase their publication performance significantly. Industry grants may thus not have much to compromise. On the contrary, we expect public and industry grants to function as complements when industry-sponsored research results in novel insights and applications that commercial academics want to share with fellow academics. Thus, as for “hybrids”, the research output of commercial types may occur in the form of patent-paper pairs, which implies a complementary relationship between public and industry sponsorship for these academics. The stronger focus on applied research, however, may also mean that commercial types are more likely to be affected by secrecy concerns because of the immediate commercial viability of their research when they receive most of their funding from industry (Perkmann and Walsh, 2009). In terms of the quality of their research, we may expect that the higher visibility due to commercialisation could result in more citations to academic research. At the same time, for commercial types, the lack of basic research may only result in publications that receive few citations.

Moreover, industry grants may also be associated with more patent applications for “hybrid” and commercial types (see earlier studies of Hottenrott and Thorwarth, 2010 and Lawson, 2013a). The relationship between public grants and patenting is, however, less obvious ex-ante.

For each of the quadrants I to III of Figure 1, we can derive expectations on the direct and joint effects of research funding from public and industry sources. In particular, we expect:

I. Traditional types' public research grants will be associated with more ex-post publications and more citations per paper. Industry grants may yield fewer publications and the joint effect may be negative.

II. "Hybrid" types' public research grants will be associated with more ex-post publications and more citations per paper. Industry grants may also be positively related to publication outcomes, but expectations about the joint effect are ambiguous. Public grants may not affect patenting, but the effect of industry grants may be positive.

III. Commercial types' public research grants will be associated with more ex-post publications and more citations per paper. Industry grants may also be positively related to publication outcomes and we expect the joint effect to be positive. Public grants may not affect patenting, but the effect of industry grants may be positive.

For researchers with low TFS and low TFC ("others"; quadrant IV of Figure 1) the expected effects of joint public and industry funding are not clear ex-ante. Just as with commercial types industry funding might not have much to compromise as "others" do not engage in basic research. However, neither do we expect complementarities based on more applied, commercial research efforts.

4 Empirical Model

We base our empirical model about the effects of research funding on research productivity on the idea that an academic exerts different research efforts aimed at producing measurable outputs with the goal of maximising her productivity. The academic's "taste" determines her research focus. The productivity effects of research grants from different sources and, in particular, their joint effects depend on the academic's position in the two-dimensional space as illustrated in Figure 1.

We consider funding from at least two types of funding agents as inputs to the research production function.[3] External resources are crucial for scientific production (Stephan, 1996, 2012) and the number of publications is increasing with funding received from external

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[3] We distinguish public from private sector funding. Public funding may stem from UK research councils (mainly EPSRC), UK charities, UK government and the EU. See section 4.1 for details on the funding information.

sponsors (Banal-Estanol et al., 2013; Kelchtermans and Veugelers, 2011). However, while publication numbers are assumed to be non-decreasing with research input, this does not rule out diminishing returns or trade-offs between different types of resources as shown by Manjarres-Henriquez et al. (2009) and Kelchtermans and Veugelers (2011).

The production function in its most general form is then given by:

$$P_{it}(\varphi) = f\left(F_{1_{it-1}}, F_{2_{it-1}}, X_{it} | \varphi\right), \tag{1}$$

Where P_{it} are publication numbers, $F_{1_{it-1}}$ and $F_{2_{it-1}}$denote two different types of funding allocated in *t*-1, where one could be considered public, science oriented funding and the other funding from industry. X_{it} are other explanatory factors like age, rank or gender. We then include the notion of a positive increase from either type of funding with potential substitution or complementarity effects:

$$P_{it}(\varphi) = \varphi\left[F_{1_{it-1}} + F_{2_{it-1}} + F_{1_{it-1}} F_{2_{it-1}} + X_{it}\right] + \varepsilon_{it} \tag{2}$$

where φ is the vector of parameters to be estimated and ε is the error term given as $\varepsilon_{it}=u_{it}+v_i+\tau_t$, where v_i is the unobserved individual effect, and τ_t is the time fixed effect.

Thus, to estimate the existence and extent of any complementary or substitution effect between different types of funding we interact the two funding variables and estimate their joint effect.

We estimate count data models as the number of publications are by nature positive and the data is characterised by a large number of zeros. We assume the outcome variables to have a negative binomial distribution and use a model that accounts for the skewed nature of the data. As we can expect decreasing marginal returns to funding even if it comes from the same funding source, we also include the quadratic term thus employing a specification of the form:

$$\begin{aligned} &E(P_{it}) = \\ &exp\{\beta_0 + \beta_1[F_{1_{it-1}}] + \beta_2[F_{1_{it-1}}]^2 + \beta_3[F_{2_{it-1}}] + \beta_4[F_{2_{it-1}}]^2 + \beta_5[F_{1_{it-1}} F_{2_{it-1}}] + \\ &\beta_6[F_{1_{it-1}} F_{2_{it-1}}]^2 + \beta_7\left[(F_{1_{it-1}})^2 F_{2_{it-1}}\right] + \beta_8[F_{1_{it-1}}(F_{2_{it-1}})^2] + \gamma X'_{it} + \varepsilon_{it}\} \end{aligned} \tag{3}$$

In the case of continuous variables in non-linear models the interaction effect is the cross-derivative of the expected marginal change in publications. For example, the marginal effect of funding $F_{1_{it-1}}$ on our dependent variable P_{it} is derived as the first derivative of (3):

$$\frac{\partial E(P)}{\partial F_1} = (\beta_1 + 2\beta_2 F_1 + \beta_5 F_2 + 2\beta_6 F_1 F_2^2 + 2\beta_7 F_1 F_2 + \beta_8 F_2^2) E(P) \qquad (4)$$

Then, derived from (4) the marginal change of funding ${F_1}_{it-1}$ on the dependent variable P_{it} with respect to the interaction term ${F_2}_{it-1}$ can be written as:

$$\frac{\partial E(P)}{\partial F_1 \partial F_2} = (\beta_5 + \beta_6 F_1 F_2 + \beta_7 F_1 + \beta_8 F_2) E(P) + (\beta_1 + 2\beta_2 F_1 + \beta_5 F_2 + 2\beta_6 F_1 F_2^2 + 2\beta_7 F_1 F_2 + \beta_8 F_2^2)(\beta_3 + 2\beta_4 F_2 + \beta_5 F_1 + 2\beta_6 F_2 F_1^2 + +\beta_7 F_1^2 + 2\beta_8 F_2 F_1) E(P) \qquad (5)$$

Any two types of funding are classified as complements if the sign of the cross derivative is positive, i.e. if an increase in industry funding increases the marginal utility of public funding. If instead, an increase in industry funding decreases the productivity gains of public funding they are considered as substitutes on the outcome variable P_{it}. If the cross-derivative is zero then we would observe a purely additive relationship between the two types of funding where one could replace the other without compromising its marginal utility.

In addition to publications, we also estimate the effect of different types of funding on patenting propensity. We estimate logistic regressions as the number of patents per year is very small and equal to one in most cases. The cross-derivative is then derived as:

$$\left. \partial E(Patent) / \partial F_1 \partial F_2 \middle/ 1 + \partial E(Patent) / \partial F_1 \partial F_2 \right. \qquad (6)$$

We estimate pooled models, which have the advantage that they relax the strict exogeneity assumption of a fixed effects model. However, they do not control for unobserved individual heterogeneity (v_i). In our case such unobserved effects could be specific skills of each academic that are positively correlated with the right hand side variables such as external funding and a potential endogeneity problem arises. For example, the literature suggests that more able academics have many more opportunities to receive funding as grant awarding bodies screen academics for their ability and sponsor the most productive. If unobserved individual heterogeneity were present, the estimated coefficient of the funding variables would be upwards biased. We can cope with this challenge if pre-sample information of the dependent variable is available. Specifically, Blundell et al. (1995, 2002) suggest a solution which controls for individual heterogeneity by specifying the average productivity of the academic before she enters the sample. The pre-sample mean of the dependent variable is a consistent estimator of the unobserved individual effect if it mainly corresponds to the intrinsic ability of an academic and her motivation, both factors that are not directly observable but may affect scientific productivity. Following Blundell et al. (1995, 2002) we can therefore account for unobserved individual heterogeneity by using pre-sample information of publications and citations. We include the log of the average number of publications published in a pre-sample period (in the period 1998 to 2000). In cases where the pre-sample value is zero, we include a dummy to capture the "quasi-missing" value.

Theory further suggests that research activity is subject to dynamic feedback (Dasgupta and David, 1994) as each academic's performance is driven by cumulative unobserved factors (u_{it}), e.g. learning, which are not controlled for through fixed effects. Blundell et al. (1995) therefore argue that it is important to consider continuous, sample-period dynamics when modelling research outcomes. To proxy for dynamic feedback within the sample period we calculate the stock of publications (and citations and patents) published during the observation period. We assume that knowledge does not depreciate during the short sample period considered here (6 years).

The pre-sample value and the stock variable are included in all estimations. This dual approach helps to address the problem of endogeneity that arises from correlated individual effects and through feedback from the dependent variable.

5 Data

This paper evaluates the possible joint effects of different types of external sponsorship on publications, citations and patent output, using data on external public research grants and industry funding for UK engineering academics. External grants represent research funding that an academic receives in addition to the university's core funding.

To gain access to grant information for academics, we contacted 40 UK universities with engineering departments[4]. Fifteen of these universities sent detailed records containing information on private and public research grants received by their engineering staff during the period 2001 to 2007[5] (see Table A1 in the Appendix for a list of universities). We manually matched the funding information with name and rank information, as well as with

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[4] The 40 universities were selected based on a list of universities, for which staff and publication data had been collected as part of the ESRC project described in Banal-Estanol et al. (2013).

[5] 6 more universities sent partial information, e.g. industry funding or researcher names were missing. For some of the 15 universities funding is available for earlier years, e.g. for 3 from 1990 onwards, for another 7 from 1996 onwards. Funding was available until 2007 The period 2001 to 2007 is the preferred period for this analysis as it covers a larger number of universities and represents the assessment period for the 2008 Research Assessment Exercise (RAE). The research information can therefore be expected to be fairly standardised across the 15 institutions and adjusted to the requirements of the RAE.

their publication records[6]. We supplemented this data with PhD year and subject information for all 885 academics that worked at the 15 universities at least during the whole period 2001 to 2006 (or 2007), whether they received funding or not. After exclusion of incomplete records, the final data set contains 809 engineering academics. Of these academics, 58% received some external funding at least once during the six-year observation period.

5.1 Descriptive statistics

Research Output

The descriptive statistics for the sample are reported in Table 1, correlations between the variables are reported in Table 2. The main variables of interest are research output and its quality, which we measure using academics' publication records. Publications were obtained from the ISI Web of Science database. We collected publications for all the years 1998 up to 2007, matched names based on last name and first initial and we cleaned all database entries manually to assure correct matching of publications to individual academics.

Funding could have a different impact on research quality than it has on research quantity. Therefore, we include a measure for research quality using the average number of citations received before the end of 2012 by articles published in *t*. In other words, for publications published in 2002 we consider a citation window of ten years while for publications published in 2007 we consider a citation window of five years.[7]

To summarize, we measure publication output as the number of publications in *t* (*PUBLICATIONS*) and quality as the average number of citations received by publications published in *t* as of 2012 (*CITATIONS*). The mean number of publications during the observation period is 2.22 per academic per year and the mean citation count for these publications is 7.68. Further, 10% of the academics in our sample did not publish during the entire six year period and 25% published less than one paper per year.

We also measure the effect of funding on patents as additional dependent variable to account for alternative dissemination paths of academics (*PATENT*). We obtain patent data from

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[6] The original data was collected based on staff registers in academic calendars and the name entries used as basis for gathering publications, patents and research council funding information for engineering academics at 40 UK universities for the period 1985 to 2007 (Banal-Estanol et al., 2013).

[7] Citation counts are inherently truncated because at any point in time when collecting the citation count per article we may naturally miss out citations to that publication in the future. However, Hall et al. (2005), stress for the case of patents that the bulk of citations usually occurs early in a patent life cycle, and more precisely in a three to ten-year window. Similar results are found for the development of publication citations (Glänzel et al., 2003; Adams, 2005) Thus, even a five-year window should capture the peak in citations for each publication.

esp@cenet (the European Patent Office (EPO) web-interface). The web-interface allows searches for patent applications filed with the EPO, the UK Intellectual Property Office (UKIPO), the US patent office (USPTO) and other national patent offices. Database construction required a manual search in the inventor database to identify those entries where the identity of the academic was certain. We did this by comparing addresses, titles and technology classes for all patents potentially attributable to each academic. We did not only consider patents filed by the universities themselves, but also those assigned to third parties, e.g. industry or government agencies.[8] As each invention can lead to multiple patent applications (e.g. at different patent offices), we additionally verified each entry with the International Patent Documentation Center (INPADOC) that contains information grouped around a patent family, enabling us to uniquely identify the original invention and avoid multiple counts. In the remainder of the paper the term patent will refer to patent families grouped around an original priority patent (as defined in INPADOC) and not to individual patents or patent applications. We recorded the filing date of the patent as this represents the closest date to invention. The average number of patents per year is 0.08 and 0.30 amongst those with at least one patent during the observation period.[9]

Table 2 shows that – as expected – patents and publications are moderately correlated. We therefore include the lagged number of patents in the publication equations and vice versa as previous research has shown that publications and patent outputs tend to be correlated (Agrawal and Henderson, 2002).

[Tables 1 and 2 about here]

For all three measures, we generate three-year pre-sample means (*Pub_Mean, Cit_Mean, Pat_Mean*) for the period 1998 to 2000, and a stock variable (*Pub_Stock, Cit_Stock and Pat_Stock*) for the years following 2000. These are included in all models to control for the

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[8] Lawson (2013b) showed that in UK engineering more than 50% of inventions are not owned by the university but by private firms, government or individuals.

[9] Also in the case of patents one could use citations as measures of quality, however, these are affected by ownership and by the norms of the respective patent office and are therefore not considered here. Moreover, most patents in our data are still being examined and have not as yet entered regional phase (in case of Patent Cooperation Treaty patents), which makes the use of patent-based citation measures problematic. Only a few patents had been granted when most of the patent data was collected in 2012, either at the EPO or at a regional office and less than 10 EPO patents had received any citations.

ex-ante scientific quality of the academic (time-invariant unobserved heterogeneity) and dynamic feedback (time-variant unobserved heterogeneity).[10]

Research Funding

The research income information obtained from the 15 universities includes the name of the principal investigator as well as data on funding source, award date, grant period and funding amount. We can attribute grant-based income to: (1) industry and business, (2) public funding agents, including UK research councils (mainly EPSRC), UK charities, UK government and EU. The average length of the grants is 3 years for public grants and 2.9 for industry grants. This difference is small but significant. The amount of funding is significantly higher for public grants with an average of more than 150,000 per grant and only 60,000 for industry grants. All funding amounts were split across the award period to avoid focussing the entire amount at the start of the grant and to account for the length of the research project. In other words, if the grant lasted two years we split it equally across those two years, if it lasted over three or more years, the first and the last years (which are assumed to not represent full calendar years) received half the share of an intermediate year. This was done in order to account for the on-going benefits and implications of a project.

We use funding received in *t*-1 to capture the impact of financial resource on scientific productivity in *t*. We firstly look at the overall effect of external funding (*FUNDING*). Then, we differentiate between funding received from industry and from public agents which includes UK research council and UK charity funding, EU funding and government funding.

After excluding some outliers[11] academics receive on average £32,000 per year in external funding. Industry funding amounts to approximately £6,000 per academic per year, while public funding provides approximately £26,000 on average, with the majority being sourced from UK research councils and charities (circa £20,000). If we only consider academics that receive some funding during the observation period, the average amount of external funding per year is £53,000 with approximately £9,000 coming from industry and £40,000 from public sponsors. The majority of academics receive funding from more than one type of

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[10] Regressions do not suffer from multicollinearity when stock and pre-sample measures are included. The collinearity diagnostics show a vif (variance inflation factor) < 2 for all stock and pre-sample measures.

[11] Outliers were identified using average values of leverage and (normalized) residuals following a linear regression of funding on publication outputs and are excluded using DFFITS (Belsley et al., 1980). We follow Bollen and Jackman (1990) and exclude observations with DFFITS>1, meaning that the observation shifts the estimate by one standard deviation. We repeat the process for all funding variables and in total exclude 14 observation, most of which are EU funding outliers.

funding agent during the observation period. 42% of academics, however, receive no external funding at all. Of those that receive external funding at least once, 60% are sponsored by industry (35% of the total sample). In terms of funding volume, UK research council and charity funding accounts for 65% of all external research income, funding from industry accounts for 17%, followed by EU with 11% and UK government with 8%.

Looking at funding received during one period, we find that 42% of funded academics receive public and industry funding simultaneously at least once. Table 2 reports the correlation between different types of funding and the three outcome measures. We find a strong positive correlation between public and industry funding. Publication numbers correlate strongest with research council and industry funding; citations are only weakly correlated with funding; patents are strongest correlated with industry funding.

Control variables

We account for academic rank by including a dummy variable that takes the value one if the academic was a professor in *t*-1 *(PROFESSOR)*. Academic rank information was obtained from university websites. Professors may have more resources available than lower ranked academics and may thus benefit more in terms of publication output than junior academics. The rank variable is lagged by one period to allow for publication delays and avoid simultaneity with our outcome measure. *PROFESSOR* is strongly correlated with publication numbers and to a lesser extent with publication quality. Further it is moderately correlated with all our funding measures.

We control for gender (*FEMALE*) as previous literature has found a gender bias in both funding and academic productivity (Stephan, 2012). Women account for 7% of academics in our sample. Table 2 shows that the gender dummy is not highly correlated to any of our main explanatory variables. We only find a negative significant sign for correlation with EU funding.

To account for other individual effects, we collected personal information of academics based on PhD data. PhD information was taken from *Index to Theses*, an online database which lists theses accepted for higher degrees by the universities of the UK and Ireland. It provides information on PhD institution, year and subject area. For academics not listed in the database we searched their websites and gathered PhD details from the library catalogues of the PhD awarding university[12]. Of the 809 academics for which personal information could be collected, 56 do not hold a PhD. As for the remaining 753 academics, they received their PhDs between 1958 and 2006, with a mean PhD award year of 1984. The degrees come from 58 UK universities and more than 30 different institutions in 16 countries outside the UK. Based on the PhD information we include the academic's academic age (*PHD_AGE*) as the difference between the current year and the year of the PhD as a control to account for life-cycle effects. The correlation matrix shows that *PHD_AGE* is moderately correlated with our outcome variables but only weakly with the funding measures. We further include a dummy for those academics that do not hold a PhD (*NO_PHD*), which represents 7% of the sample.

Subject specialisation is based on the subject of the PhD as department division is not consistent across the 15 universities. In our sample 22% of academics graduated in electrical and electronic engineering (*ELECTRICAL*), 21% in civil engineering (*CIVIL*), 15% hold a PhD in chemical engineering (*CHEMICAL*), 15% in physics (*PHYSICS*) and 13% in mechanical engineering (*MECHANICAL*). Just 8% have a background in life sciences (*BIO*). The correlation table shows some important differences by scientific field. Physics and chemical engineering are strongest correlated with our outcome measures. Physics is also positively correlated with funding, while civil engineering correlates negatively with all types of funding and the outcome measures.

Year and university dummies are included in all regressions to control for potential institution or time fixed effects. Due to the short panel window institution specific measures (e.g. size, income) are not included as they do not differ significantly across time and any differences should be captured by the university fixed effect.[13]

5.2 Analysis of funding profiles

Table 3a reports descriptive statistics by type of funded academic. Academics are allowed to move between groups depending on their funding status in *t*-1. We differ between observations where an academic receives (1) no public or industry funding, (2) only industry funding, (3) only public funding and (4) both, industry and public funding. The basic descriptive results show that all four groups are significantly different on most of our

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[12] This concerned some PhDs awarded in the UK that were not submitted to *Index to Theses* as well as PhDs awarded outside the UK and Ireland.

[13] Mobility of academics across institutions is limited in our sample period. We observe as few as nine individuals who move from one institution to another.

variables. They also show that researchers receiving funding produce more publications than those who do not. However, only for academics with some public funding this difference is significant. Further, academics receiving industry *and* public grants are most productive. This result also holds when looking at average citation numbers. This group of highly sponsored and diversified academics is also the group producing the largest number of patents. This is in line with the literature on star scientists (Zucker and Darby, 1996; Zucker et al., 2002) that suggests strong complementarities between high scientific ability, commercialisation and funding success. The descriptive results thus support our assumption of a positive production function and point towards a complementary relationship between public and private sector grants for all research outputs.

In terms of funding amount, it becomes clear that academics that source funding from more than one source raise significantly more funding than academics that rely on just one source. This suggests that as public grants are distributed based on peer review and can be expected to benefit the most able academics, industry may look at public grants to inform their own funding decision and to identify potential partners for research (Perkmann et al., 2013).

In terms of control variables, we make some interesting observations. Significantly fewer female academics can be found amongst the group of academics that receive funding from industry alone. Academics without a PhD are significantly less represented in the groups of funded academics, suggesting that they are less research but perhaps more teaching oriented. Age is significantly higher in the groups of academics receiving public funding and highest amongst the top performing group that also includes the highest share of professors. We can further see that different scientific fields attract different types of funding. Academics in bioscience are significantly more represented in the group that attracts funding from several sources, while academics in physics are focussing on one agent at a time. Researches in mechanical engineering are more likely to be found amongst funded academics, while academics in chemical engineering are mostly found amongst those receiving no or only public funding. Electrical and electronic engineering faculty are less likely to solely source funding from industry, while civil engineering academics are more likely to be found amongst this group.

[Tables 3a and 3b about here]

5.3 Analysis of "Taste" profiles

Table 3b reports descriptive statistics by the taste for science and commercialisation of academics. We do not allow academics to change between groups but evaluate them based on their overall sample period profile. We base our TFS measure on the journal classification by Narin (1976) that distinguishes between basic and applied type journals. Based on cross-citation matrices between journals, it distinguishes between four categories where 1 is the most applied and 4 the most basic ((1) applied technology, (2) engineering and technological science, (3) targeted basic research, and (4) basic scientific research). We consider academics to have a high taste for science if they published at least one article in a basic research oriented journal (3 or 4) during the observation and pre-observation period. This being a sample of engineering academics there is a bias towards applied research and basic research publications are not as common as in other fields of research. Our TFC measure is based on patent applications filed by the respective academic. If the focal academic applied for at least one patent during the observation and pre-observation period he or she is considered to have a taste for commercialisation. In our sample 45% can be considered traditional academics (quadrant I), 8% are commercial types (quadrant III) and 19% can be considered "hybrids" (they both patent and publish basic research articles, quadrant II).

In Table 3b we show how the input and output measures of our estimations differ by the type of academic. The descriptive statistics show that "hybrid" academics, those with a high taste for both science and commercialisation publish most articles and receive most citations. They also have the highest amount of research income from both industry and public sources. All the other groups perform less well in terms of both publications and citations and receive significantly less funding. The group of "others", who show no strong taste for science or commercialisation, also attract least funding. In terms of patent numbers, we do not find a significant difference between "hybrids" and commercial types.

In Table A2 we additionally report descriptive statistics for all control variables for all four groups of academics. Significantly more professors can be found amongst the group of "hybrid" academics. Academics with a high TFC are also significantly older than traditional scientists or those that are least research active ("others"). Academics without a PhD are significantly more represented in the group of "others", suggesting that they are less research but perhaps more teaching oriented. Female academics are also more likely to be amongst those with low TFS, either as “commercial types” or “others”. We can further see that different scientific fields attract or foster different types of academics.

6 Results

6.1 Baseline results

We firstly estimate the effects of funding on publication outcomes without differing between funding types to look at the overall effect of grant-based funding. Table 4 reports the results for publication and citation outcomes. Standard errors are robust and clustered at the individual level. The results show that external funding has a positive, although decreasing effect, on publication outcomes, supporting our positive production function assumption. We find decreasing returns for both public and industry grants on the number of publications, but not on their citations. For patenting propensity we find no significant effect of funding unless we consider the interaction between public and private funding. Only in the regressions in Table 5 do we find a positive effect of industry funding on the propensity to patent, albeit with decreasing marginal returns.

The control variables are consistent across the different specifications. Patents show a positive correlation with publication and citation numbers though the effects are insignificant in columns 1 to 4. Professors publish significantly more and of higher quality than junior academics and also have a higher propensity to file a patent, perhaps due to their experience and better access to resources. We do not find a significant difference between the publication and patenting rates of men and women. Academics that do not hold a PhD also produce significantly fewer publications, receive fewer citations and are less likely to file a patent than their peers, indicating that they may focus primarily on teaching. Productivity, publication quality and patenting propensity declines with age. Publication and average citation numbers are lower in more applied fields of engineering and lowest in civil and mechanical engineering. Patenting propensity is highest for academics in electrical engineering, physics and the life sciences. University fixed effects and year effects are jointly significant. Our pre-sample mean and the dynamic feedback variables are both positive and significant pointing at the importance of controlling for individual unobserved effects.

[Table 4 about here]

As mentioned earlier, we distinguish two types of funding: industry grants and non-profit sources. When we split the public, non-profit sources into funding agent (Research Councils and charities, other government funding and EU grants), we find that they all work in the same direction. That is, they generally provide a positive effect, albeit with decreasing returns. Remarkably, EU funding has a strong impact on the average number of citations per publication, whereas the impact on citations of other public funding channels is less pronounced (see Table A3 for the details).

6.2 Results with funding interactions

We secondly estimate the effect of different types of funding and their interactions on publication outcomes. For a correct interpretation of the interaction variable, we calculate the cross-derivative for the joint effect of public and industry income holding all variables at their mean (following eq. (5) and (6)). Table 5 shows the marginal effects of the key funding variables at different values of the funding distribution. The cross-derivative of the interaction term is negative and significant ranging from -0.207 to -0.305 for publication counts, indicating that while public funding positively correlates with publication numbers, the joint effect of industry and public funding is negative, offsetting part of the positive productivity effect of public grants. For citations, we find the squared interaction term to be negative and significant pointing to a quality-reducing effect only at higher values of joint funding. For patents we find a negative interaction effect for low levels of industry and public funding below the sample mean but a positive interaction effect for mean and high levels of joint funding. This suggests that public and private funding act as complements in the production of commercial outputs when higher amounts of funding are received from both sponsors. This is particularly interesting as public funding has no independent positive effect on patenting in these equations.

[Table 5 about here]

6.3 Results by "Taste" type

Table 6 shows the marginal effects of the funding variables and their interactions by researcher type. As with the baseline case, we find a positive effect of public grants for all types, except "others". Industry funding is positive for traditional scientists and "others". For high values of industry funding, however, the effect turns negative, whereas for commercial types the positive effect of industry funding increases as funding amounts increase. The most interesting result is the difference in the interaction effect of public and industry grants between types of academics. For traditional scientists the marginal interaction effect is -1.802. For "hybrids" it is notably smaller (-0.595) suggesting that the publication output of "hybrids" is less compromised by industry sponsored research than that of traditional scientists. For commercial types the interaction effect is even positive and relatively large (7.795) pointing to strong complementarities of public and private funding for these academics. For "others" the interaction effect is insignificant.

Further, we find a strong positive complementary effect of public and private funding on the average number of citations received by publications of commercial types. To a lesser extent, for traditional scientists and "hybrids", citation numbers are lower only for high values of both types of funding. When we consider patents as a productivity measure, we find that the interaction effect and its squared term is positive for commercial types, but not for "hybrids". Public grants or industry grants alone do not significantly impact the likelihood to patent.

[Table 6 about here]

Figure 2 illustrates the effect of industry funding on the marginal effect of public funding on publication numbers for all four types. From the upwards (downwards) sloping lines, we see the complementary relationship in the quadrant of the commercial types (traditional types). "Hybrids" show a similar pattern to the one of traditional scientists, but the substitutive effect is less pronounced. First, we find that for traditional scientists simultaneous funding from industry compromises positive productivity effects from public grants. This effect is somewhat weaker for "hybrid" academics. For commercial types, however, we find an increase in research productivity in terms of quantity and quality of publications and patents where research funding is obtained from both sources.

The control variables also expose some interesting differences across types of academics. Professors publish significantly more in all groups accept "hybrids". "Hybrid" professors also do not file more patents than younger "hybrids", though we find a significant difference for commercial types. Professors in all groups except for "others" also have higher mean citation counts. While we did not find a significant difference between the publication and patenting rates of men and women in the baseline regressions in Table 4, we now find that women with a high TFC receive more citations than men, while those with low TFC publish less and of lower quality than men. "Hybrid" women are less likely than men to file a patent. Academics that do not hold a PhD also produce significantly fewer publications, receive fewer citations and are less likely to file a patent than their peers in all groups of academics. The negative age effect is also consistent across all four types.

7 Conclusions

This paper empirically investigated the existence of complementarities between public and private grant-based research funding on scientific performance. The question is particularly critical as core budgets are at best stagnating and academics are increasingly looking at other channels to support their research. Industry-sponsored relationships can provide ideas and resources for research that may open up new research lines (Mansfield, 1995). If this is the case then the expected benefits from public funding could also increase based on positive complementarities. On the other hand, previous research has also expressed concerns that industry partners may direct academics towards applied research and limit or delay the dissemination of research results (Blumenthal et al., 1986, 1996; Cohen et al., 1998, Czarnitzki et al. 2011). If sponsors induce a shift of research topic or require secrecy then also public funding placed with such industry sponsored academics may suffer limitations and the marginal utility of public grants may decrease.

Our results suggest that the direction of this effect depends on the type of academic. Using a typology that distinguishes between academics with a “taste for science”, “taste for commercialization”, taste for both (“hybrids”) or taste for neither, this study examined a sample of academics in engineering regarding the joint effects of public and private sector grants. Controlling for unobserved heterogeneity, we find that industry funding decreases the marginal effect of public grants on publication outcomes for “traditional academics” with a high taste for science, but a low taste for commercialisation. The joint effect was considerably smaller, but still negative, for “hybrids”. These results point to the conclusion that academics with a high “taste for science” may find it more difficult to recognise and realise potential complementarities between their publicly funded work and industry-sponsored projects. It may also imply that basic research undertaken by traditional scientists is least compatible with industry led projects.

Conversely, for “commercial types” with a high taste for commercialisation and a low taste for science, we find that industry grants stimulate publication output. Moreover, we find that public and industry grants are also complements for the likelihood that a “commercial type” academic files a patent application. These insights suggest that “commercial types” do realise complementarities between projects from public and industry sponsors, and that this not only spurs commercial output in the form of patents, but also increases publication numbers.

These results also hold for quality-weighted publication output. While “traditional scientists” (and to a lesser extent “hybrids”) publish fewer and less impactful articles, “commercial types” achieve a quality increase as a result of public and private co-sponsorship.

The results help to inform the debate on how industry and public funding jointly affect research productivity. In terms of policy implications we can conclude that co-sponsorship may affect different types of academics differently. It seems important to provide public grants to fund academics with a “taste of science” to allow them to focus their research efforts without the distraction of work for other sponsors. Private sector grants may nevertheless be very valuable to those academics who are capable of combining publicly financed research with industry projects. For these academics the complementarities between grants open up additional publications and patents that would not have been achieved without multiple sources of funding.

This study is a first step to unleash the interactions between different types of external funding for different types of academics. We concentrated on the field of engineering, which is traditionally associated with applied research and industry relations. We therefore strongly encourage further research taking into account other disciplines as funding environments continue to shift. The evidence presented here shows that this shift may not be without consequences for the development of the science base, even in applied sciences like engineering. Ours can only be a first attempt and more research is clearly needed to pin down the mechanisms behind the effect of industry grants that can be so different on different types of academics. Negative effects for traditional scientists, for example, could be due to non-disclosure clauses or research topics less relevant to science. Blumenthal et al. (2006) and Czarnitzki et al. (2011) show evidence of secrecy clauses for academics with industry grants that may also affect the release of publications from public grants. Hottenrott and Lawson (2014) further suggest that ideas from industry may not always lead to better research performance, perhaps by simply not being relevant to science (see Perkmann and Walsh, 2009). With the comparability of our results in mind, we suggest further research on the dynamics underlying the sponsoring-research outcome relationship in both qualitative and quantitative approaches. In particular, the debate on research funding would benefit from investigating if and how funding relationships affect not only short-term scientific outcomes but also the shaping of scientific careers. Academics may specialise in certain types of grants and sponsors, and hence the type of research output they pursue.

This paper also shows that a group of academics exists with a taste for neither science nor commercialisation, which is less involved in research. We provide some weak evidence that these academics can draw benefits from contracts with industry, primarily due to their inability to access competitive public funding. As these academics may focus primarily on teaching, the consequences of their links to industry for students could be of importance.

Finally, it is important to stress that this study does not evaluate other benefits that may come from co-sponsorship. A more comprehensive assessment is therefore needed to establish any benefits for students, teaching or commercialisation of research as well as benefits for the sponsoring firms, which would contribute to the social returns from science and may therefore be of greater policy relevance than publications in scientific journals.

Appendix

[Table A1, A2, A3 here]

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Tables

Table 1: Descriptive statistics (4,796 observations)

	mean	sd	min	max
Productivity measures				
PUBLICATIONS_{it} (Publication number)	2.22	3.18	0	32
CITATIONS_{it} (Mean citation number)	7.68	13.53	0	391
Patent measure				
PATENT_{it} (Patent dummy)	0.06	0.24	0	1
$\text{PATENT\_NUMBER}_{it}$	0.08	0.40	0	6
Funding measures(in 100,000 GBP)				
FUNDING_{it-1}	0.32	0.95	0	12.12
$\text{PUBLIC\_FUNDING}_{it-1}$	0.26	0.84	0	11.67
$\text{INDUSTRY\_FUNDING}_{it-1}$	0.06	0.27	0	7.22
RC_FUNDING_{it-1}	0.20	0.77	0	11.15
EU_FUNDING_{it-1}	0.04	0.17	0	3.02
$\text{GOV\_FUNDING}_{it-1}$	0.02	0.14	0	2.39
Individual characteristics				
PROFESSOR_{it-1}	0.34	0.47	0	1
FEMALE_{i}	0.07	0.25	0	1
NO_PHD_{i}	0.07	0.25	0	1
PHD_AGE_{i}	18.60	10.47	0	49
BIO_{i}	0.07	0.26	0	1
PHYSICS_{i}	0.15	0.36	0	1
MECHANICAL_{i}	0.13	0.34	0	1
ELECTRICAL_{i}	0.22	0.41	0	1
CHEMICAL_{i}	0.15	0.36	0	1
CIVIL_{i}	0.21	0.41	0	1
Individual heterogeneity measure				
PUB_Mean_{i}	1.99	2.55	0	26
CIT_Mean_{i}	11.71	26.43	0	597.50
PAT_Mean_{i}	0.08	0.34	0	4.67
PUB_Stock_{it-1}	7.23	11.17	0	146
CIT_Stock_{it-1}	29.94	42.36	0	445
PAT_Stock_{it-1}	0.31	1.12	0	23

Table 2: Correlation matrix (4,796 observations)

		1	2	3	4	5	6	7	8	9	10	11	12	13
1	PUBLICATIONS$_{it}$	1.000												
2	CITATIONS$_{it}$	0.334***	1.000											
3	PATENT$_{it}$	0.140***	0.068***	1.000										
4	FUNDING$_{it-1}$	0.235***	0.077***	0.089***	1.000									
5	PUBLIC_FUNDING$_{it-1}$	0.204***	0.070***	0.061***	0.960***	1.000								
6	INDUSTRY_FUNDING$_{it-1}$	0.185***	0.051***	0.119***	0.506***	0.244***	1.000							
7	RC_FUNDING$_{it-1}$	0.178***	0.062***	0.048***	0.913***	0.963***	0.194***	1.000						
8	EU_FUNDING$_{it-1}$	0.133***	0.035**	0.062***	0.329***	0.318***	0.159***	0.113***	1.000					
9	GOV_FUNDING$_{it-1}$	0.088***	0.035**	0.025*	0.350***	0.326***	0.208***	0.149***	0.106***	1.000				
10	PROFESSOR$_{it-1}$	0.313***	0.135***	0.101***	0.273***	0.252***	0.169***	0.223***	0.131***	0.128***	1.000			
11	FEMALE$_{i}$	0.023	-0.004	-0.018	-0.016	-0.023	0.012	-0.014	-0.031**	-0.022	-0.062***	1.000		
12	NO_PHD$_{i}$	-0.137***	-0.090***	-0.049***	-0.009	-0.007	-0.009	-0.004	-0.047***	0.037***	-0.107***	-0.035**	1.000	
13	PHD_AGE$_{i}$	0.135***	0.047***	0.026*	0.042***	0.026*	0.065***	0.016	0.038***	0.018	0.433***	-0.116***	-0.484***	1.000
14	BIO$_{i}$	0.021	0.100***	0.037**	-0.005	-0.009	0.009	0.001	-0.026*	-0.025*	0.038***	0.054***	-0.077***	0.119***
15	PHYSICS$_{i}$	0.146***	0.055***	0.043***	0.087***	0.078***	0.063***	0.073***	0.043***	0.015	0.090***	-0.058***	-0.114***	0.200***
16	MECHANICAL$_{i}$	-0.042***	-0.045***	-0.045***	0.014	0.003	0.042***	-0.005	0.023	0.017	-0.037**	-0.006	-0.106***	-0.027*
17	ELECTRICAL$_{i}$	-0.019	-0.044***	0.076***	-0.003	-0.002	-0.004	-0.007	0.029**	-0.009	0.034**	-0.060***	-0.144***	0.045***
18	CHEMICAL$_{i}$	0.145***	0.094***	-0.002	-0.044***	-0.031**	-0.058***	-0.019	-0.055***	-0.015	0.031**	0.109***	-0.114***	0.084***
19	CIVIL$_{i}$	-0.128***	-0.057***	-0.069***	-0.038***	-0.031**	-0.035**	-0.033**	0.008	-0.012	-0.068***	0.007	-0.140***	-0.047***

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 3a: Means by funding structure

	1	2	3	4	5
Funding	No funding	Public=0; Industry>0	Public>0; Industry=0	Public>0; Industry>0	Anova F-Test Sig.
Observations	2851	303	1105	537	
Researcher IDs	651	140	365	194	
Productivity measures					
PUBLICATIONS$_{it}$	1.72	1.92	2.68***	4.09***	***
CITATIONS$_{it}$	6.59	6.92	9.15***	10.90***	***
Patent measure					
PATENT$_{it}$	0.04	0.06	0.07***	0.13***	***
PATENT_NUMBER$_{it}$	0.06	0.07	0.11*	0.20***	***
Funding measures (in 100,000 GBP)					
FUNDING$_{it-1}$	0.00	0.22***	0.62***	1.42***	***
PUBLIC_FUNDING$_{it-1}$	0.00	0.00	0.62***	1.05***	***
INDUSTRY_FUNDING$_{it-1}$	0.00	0.22***	0.00	0.38***	***
RC_FUNDING$_{it-1}$	0.00	0.00	0.48***	0.80***	***
EU_FUNDING$_{it-1}$	0.00	0.00	0.09***	0.13***	***
GOV_FUNDING$_{it-1}$	0.00	0.00	0.05***	0.11***	***
Individual characteristics					
PROFESSOR$_{it-1}$	0.25	0.35***	0.45***	0.61***	***
FEMALE$_{i}$	0.07	0.04**	0.07	0.06	**
NO_PHD$_{i}$	0.09	0.06*	0.03***	0.03***	***
PHD_AGE$_{i}$	18.20	17.83	18.95**	20.41***	***
BIO$_{i}$	0.07	0.06	0.08	0.10**	***
PHYSICS$_{i}$	0.13	0.16	0.18***	0.16*	***
MECHANICAL$_{i}$	0.12	0.17***	0.14*	0.16***	***
ELECTRICAL$_{i}$	0.22	0.19	0.21	0.23	n.s.
CHEMICAL$_{i}$	0.16	0.11***	0.15	0.10***	***
CIVIL$_{i}$	0.20	0.25**	0.22	0.22	**

Note: Stars in columns 2-4 indicate significance of mean comparison with column 1 (observations with no funding). Analysis of variance (column 5) compares the four groups of researchers. *** p<0.01, ** p<0.05, * p<0.1

Table 3b: Pairwise mean comparison tests by type of academic

	(1) traditional	**(2) hybrid**	**(2) commercial**	**(4) other**
Observations	2162	938	393	1303
Researcher IDs	364	158	66	221
		PUBLICATIONS$_{it}$		
Mean	2.02***	3.61***	2.64***	1.43***
diff = mean(#)-mean(1)		1.59***	0.63***	-0.59***
diff = mean(#)-mean(2)			-0.96***	-2.18***
diff = mean(#)-mean(3)				- 1.22***
		CITATIONS$_{it}$		
Mean	7.22***	10.59***	8.55***	6.10***
diff = mean(#)-mean(1)		3.37***	1.33*	-1.11*
diff = mean(#)-mean(2)			-2.04**	-4.48***
diff = mean(#)-mean(3)				-2.44**
		PUBLIC_FUNDING$_{it-1}$		
Mean	0.25***	0.46***	0.19***	0.15***
diff = mean(#)-mean(1)		0.21***	-0.07	-0.11***
diff = mean(#)-mean(2)			-0.27***	-0.31***
diff = mean(#)-mean(3)				- 0.04
		INDUSTRY_FUNDING$_{it-1}$		
Mean	0.04***	0.15***	0.04***	0.02***
diff = mean(#)-mean(1)		0.11***	-0.00	-0.01*
diff = mean(#)-mean(2)			-0.11***	-0.12***
diff = mean(#)-mean(3)				- 0.01

Note: *** p<0.01, ** p<0.05, * p<0.1; no difference in mean comparison between HYBRID and commercial types in terms of patent numbers.

Table 4: Marginal effects of external funding on publication outcomes

	1		2		3		4		5		6	
VARIABLES	PUBLICATIONS$_{it}$ NBREG		PUBLICATIONS$_{it}$ NBREG		CITATIONS$_{it}$ NBREG		CITATIONS$_{it}$ NBREG		PATENTit LOGIT		PATENTit LOGIT	
	dy/dx	SE	dy/dx	SE	dy/dx	SE	dy/dx	SE	dy/dx	SE	dy/dx	SE
FUNDING$_{it-1}$	0.196***	(0.060)			0.340	(0.233)			0.004	(0.006)		
FUNDING$_{it-1}^{2}$	-0.087***	(0.030)			-0.152	(0.098)			0.000	(0.003)		
PUBLIC_FUNDING$_{it-1}$			0.189***	(0.055)			0.545**	(0.268)			0.005	(0.013)
PUBLIC_FUNDING$_{it-1}^{2}$			-0.077***	(0.026)			-0.211*	(0.111)			-0.002	(0.011)
INDUSTRY_FUNDING$_{it-1}$			0.189	(0.085)			-0.897*	(0.538)			-0.002	(0.007)
INDUSTRY_FUNDING$_{it-1}^{2}$			-0.354***	(0.118)			0.100	(0.356)			0.013	(0.004)
PATENT_NUMBER $_{it-1}$	0.085	(0.073)	0.105	(0.070)	-0.314	(0.373)	-0.261	(0.371)				
PUBLICATIONS $_{it-1}$									0.002**	(0.001)	0.002*	(0.001)
PROFESSOR$_{it-1}$	0.963***	(0.141)	0.950***	(0.138)	2.961***	(0.538)	3.007***	(0.538)	0.016	(0.010)	0.017*	(0.010)
FEMALE$_{i}$	-0.145	(0.205)	-0.138	(0.202)	-1.217	(1.102)	-1.154	(1.100)	-0.018	(0.016)	-0.018	(0.016)
NO_PHD$_{i}$	-1.966***	(0.378)	-1.941***	(0.369)	-6.280***	(1.731)	-6.243***	(1.734)	-0.056**	(0.028)	-0.057**	(0.028)
PHD_AGE$_{it}$	-0.044***	(0.007)	-0.043***	(0.007)	-0.131***	(0.032)	-0.130***	(0.032)	-0.001**	(0.000)	-0.001**	(0.000)
BIO$_{i}$	0.511**	(0.209)	0.492**	(0.207)	4.075***	(0.936)	4.056***	(0.934)	0.037**	(0.015)	0.038**	(0.015)
PHYSICS$_{i}$	0.763***	(0.182)	0.765***	(0.179)	2.525***	(0.819)	2.505***	(0.819)	0.036***	(0.014)	0.036**	(0.014)
MECHANICAL$_{i}$	0.179	(0.201)	0.186	(0.198)	-0.008	(0.937)	0.084	(0.941)	-0.004	(0.016)	-0.004	(0.016)
ELECTRICAL$_{i}$	0.436***	(0.168)	0.431***	(0.165)	0.948	(0.778)	0.960	(0.778)	0.045***	(0.013)	0.045***	(0.013)
CHEMICAL$_{i}$	0.879***	(0.175)	0.855***	(0.173)	2.942***	(0.780)	2.894***	(0.783)	0.018	(0.015)	0.019	(0.015)
CIVIL$_{i}$ (Reference)												
ln[Pub_Mean]|ln[Cit_Mean]|ln[Pat_Mean]	0.313***	(0.038)	0.310***	(0.038)	1.251***	(0.249)	1.265***	(0.249)	0.008	(0.009)	0.010	(0.009)
[Pub_Mean=0]|[Cit_Mean=0]|[Pat_Mean=0]	0.793***	(0.081)	0.780***	(0.080)	-1.882**	(0.931)	-1.853**	(0.930)	-0.046***	(0.012)	-0.047***	(0.012)
Pub_Stock|Cit_Stock|Pat_Stock	-1.546***	(0.236)	-1.524***	(0.231)	0.056***	(0.011)	0.057***	(0.011)	0.022***	(0.004)	0.022***	(0.004)
Joint sign. of university dummies $\chi2$ (14)	117.29***		117.25***		96.50***		99.58***		19.71		19.86*	
Joint sign. of subject dummies $\chi2$ (5)	30.44***		30.26***		33.36***		31.92***		21.75***		21.53***	
Joint sign. of year dummies $\chi2$ (5)	13.71**		14.71**		44.61***		44.00***		16.27***		15.83***	
Log-likelihood	-8065.201		-8058.624		-13255.149		-13253.572		-889.017		-887.888	
Lnalpha	-1.022***	(0.069)	-1.033***	(0.070)	0.847***	(0.049)	0.846***	(0.049)				
Cluster	809		809		809		809		787		787	
Observations	4796		4796		4796		4796		4667		4667	

Note: Marginal effects are reported. Robust clustered standard errors in parentheses; clustered by individual researcher.
The number of observations is lower in the logit estimations as for one university failure is predicted perfectly and 129 observations therefore dropped.
*** $p<0.01$, ** $p<0.05$, * $p<0.1$

Table 5: Marginal effects for funding values and their interactions

	1	2	3	4	5	6	7	8	9	10	11	12
Dependent Variable:	PUB_{it}	PUB_{it}	PUB_{it}	PUB_{it}	CIT_{it}	CIT_{it}	CIT_{it}	CIT_{it}	PAT_{it}	PAT_{it}	PAT_{it}	PAT_{it}
Marginal effects at:	50p	75p	Mean	95p	50p	75p	Mean	95p	50p	75p	Mean	95p
Estimation Method:	NBREG	NBREG	NBREG	NBREG	NBREG	NBREG	NBREG	NBREG	Logit	Logit	Logit	Logit
$PUBLIC\_FUNDING_{it-1}$	0.225***	0.224***	0.211***	0.144**	0.568*	0.560*	0.554*	0.565**	0.013**	0.013*	0.010	-0.005
	(0.059)	(0.061)	(0.059)	(0.057)	(0.309)	(0.310)	(0.294)	(0.253)	(0.006)	(0.007)	(0.007)	(0.006)
$PUBLIC\_FUNDING_{it-1}^2$	-0.084***	-0.086***	-0.082***	-0.067*	-0.207	-0.211	-0.186	-0.131	-0.007	-0.007	-0.005	0.003
	(0.026)	(0.027)	(0.027)	(0.035)	(0.132)	(0.137)	(0.130)	(0.135)	(0.005)	(0.005)	(0.005)	(0.004)
$INDUSTRY\_FUNDING_{it-1}$	0.540***	0.503***	0.469**	0.191	-0.799	-0.816	-0.821	-0.637	0.052***	0.044***	0.038**	-0.022
	(0.197)	(0.188)	(0.183)	(0.158)	(1.253)	(1.170)	(1.055)	(0.617)	(0.017)	(0.017)	(0.017)	(0.024)
$INDUSTRY\_FUNDING_{it-1}^2$	-0.951**	-0.898**	-0.888**	-0.603***	-0.621	-0.344	-0.221	0.548	-0.163**	-0.138**	-0.134*	0.024
	(0.419)	(0.380)	(0.372)	(0.204)	(2.895)	(2.653)	(2.521)	(1.286)	(0.076)	(0.066)	(0.069)	(0.038)
$PUBLIC\_FUNDING_{it-1}*INDUSTRY\_FUNDING_{it-1}$	-0.207*	-0.22**	-0.235*	-0.305*	-0.121	-0.116	-0.110	-0.071	-0.054***	-0.494	0.053*	0.321***
	(0.106)	(0.112)	(0.121)	(0.156)	(0.638)	(0.663)	(0.666)	(0.740)	(0.023)	(0.227)	(0.029)	(0.088)
$(PUBLIC\_FUNDING_{it-1}*INDUSTRY\_FUNDING_{it-1})^2$	(-0.001)	-0.006	-0.013	-0.049	-0.653**	-0.676**	-0.682**	-0.747**	0.007	0.003	-0.007	-0.023
	(0.052)	(0.055)	(0.061)	(0.086)	(0.260)	(0.273)	(0.285)	(0.350)	(0.017)	(0.015)	(0.012)	(0.016)

Note: Marginal effects are calculated following eq. (4) - (6). All other variables are held at the mean. Robust standard errors in parentheses.
*** p<0.01, ** p<0.05, * p<0.1

Table 6: Marginal effects for funding values and their interactions for different types of academics

	1	2	3	4	5	6	7	8	9	10
Dependent Variable:	PUB$_{it}$	PUB$_{it}$	PUB$_{it}$	PUB$_{it}$	CIT$_{it}$	CIT$_{it}$	CIT$_{it}$	CIT$_{it}$	PAT$_{it}$	PAT$_{it}$
Quadrant:	Traditional	Hybrid	Commercial	Other	Traditional	Hybrid	Commercial	Other	Hybrid	Commercial
Estimation Method:	NBREG	NBREG	NBREG	NBREG	NBREG	NBREG	NBREG	NBREG	Logit	Logit
PUBLIC_FUNDING$_{it-1}$	0.163*	0.394**	0.663**	-0.012	0.565	0.796	0.736	0.359	-0.061	0.039
	(0.088)	(0.164)	(0.308)	(0.080)	(0.437)	(0.712)	(1.382)	(1.027)	(0.047)	(0.203)
PUBLIC_FUNDING$_{it-1}^{2}$	-0.042	-0.196	-0.703	0.112	-0.156	-0.275	-0.767	0.707	0.021	0.025
	(0.038)	(0.094)	(0.456)	(0.142)	(0.199)	(0.351)	(2.251)	(2.053)	(0.023)	(0.349)
INDUSTRY_FUNDING$_{it-1}$	2.106***	0.359	-1.820*	1.251***	6.042***	-3.574**	-5.017	0.573	0.092	-0.394
	(0.609)	(0.432)	(1.084)	(0.315)	(2.528)	(1.797)	(5.183)	(3.936)	(0.091)	(1.387)
INDUSTRY_FUNDING$_{it-1}^{2}$	-7.833***	-1.231	6.294*	-5.648***	-21.000**	3.937	6.762	-19.853	-0.400	3.163
	(2.299)	(0.969)	(3.354)	(1.338)	(10.344)	(4.350)	(16.863)	(18.672)	(0.484)	(10.281)
PUBLIC_FUNDING$_{it-1}$*INDUSTRY_FUNDING$_{it-1}$	-1.802***	-0.595**	7.795***	-0.086	-2.389	-1.794	35.186*	18.396**	-0.123	1.566**
	(0.596)	(0.287)	(3.646)	(0.853)	(2.318)	(1.669)	(21.095)	(9.054)	(0.180)	(0.741)
(PUBLIC_FUNDING$_{it-1}$*INDUSTRY_FUNDING$_{it-1}$)^{2}	-1.059***	-0.378	-2.72	-0.235	-2.701**	-1.282*	126.644	13.806	-0.147	0.832***
	(0.368)	(0.266)	(17.431)	(1.781)	(1.255)	(0.764)	(104.023)	(23.530)	(0.158)	(0.292)
PATENT_NUMBER $_{it-1}$	0	0.022	0.115	0	0	-0.134	-0.442	0	-	-
	(0)	(0.116)	(0.163)	(0)	(0)	(0.643)	(0.752)	(0)		
PUBLICATIONS $_{it-1}$	-	-	-	-	-	-	-	-	0.001	0.003
									(0.003)	(0.006)
PROFESSOR$_{it-1}$	0.862***	0.505	0.935**	0.603***	2.683***	3.087**	6.088***	1.351	0.027	0.126**
	(0.148)	(0.331)	(0.452)	(0.215)	(0.612)	(1.268)	(2.256)	(1.478)	(0.033)	(0.052)
FEMALE$_{i}$	-0.371*	0.679	1.022	-0.195	-0.673	7.544***	5.716**	-5.070**	-0.122**	0.064
	(0.225)	(0.485)	(0.626)	(0.300)	(1.388)	(2.402)	(2.871)	(2.457)	(0.058)	(0.116)
NO_PHD$_{i}$	-1.484***	-3.475*	-2.112	-1.379***	-3.640**	-8.093	-19.493**	-6.534*	-0.086	-0.352*
	(0.354)	(1.807)	(1.548)	(0.521)	(1.796)	(8.034)	(8.077)	(3.710)	(0.104)	(0.199)
PHD_AGE$_{it}$	-0.042***	-0.016	-0.067**	-0.037***	-0.113***	-0.005	-0.317**	-0.174**	-0.004**	0.000
	(0.008)	(0.015)	(0.029)	(0.009)	(0.040)	(0.060)	(0.143)	(0.074)	(0.002)	(0.002)
ln[Pub_Mean]|ln[Cit_Mean]|ln[Pat_Mean]	0.478***	1.565***	0.995***	0.552***	1.008***	1.842***	3.639**	1.609**	0.115***	0.093
	(0.098)	(0.266)	(0.372)	(0.138)	(0.325)	(0.541)	(1.668)	(0.646)	(0.041)	(0.079)
[Pub_Mean=0]|[Cit_Mean=0]|[Pat_Mean=0]	-0.321	-1.296*	-5.259***	-1.472***	1.449	3.508	-6.641	-5.923***	-0.010	-0.051
	(0.224)	(0.704)	(1.581)	(0.267)	(1.141)	(2.366)	(4.682)	(1.781)	(0.044)	(0.080)
Pub_Stock|Cit_Stock|Pat_Stock	0.074***	0.055***	0.039	0.049***	0.064***	0.027	0.072***	0.029	0.035***	0.001
	(0.013)	(0.017)	(0.030)	(0.014)	(0.010)	(0.018)	(0.027)	(0.018)	(0.009)	(0.011)
Joint sign. of university dummies $\chi2$ (14)	52.19***	26.58**	261.13***	171.87***	32.29***	55.14***	125.44***	83.27***	23.06**	25.41**
Joint sign. of subject dummies $\chi2$ (5)	20.77***	6.29	10.93*	9.03	26.25***	14.98**	12.69**	3.27	8.83	16.38***
Joint sign. of year dummies $\chi2$ (5)	8.59	8.50	10.68*	11.64**	29.05***	9.05	24.08***	13.54**	8.84	10.03*
Log-likelihood	-3623.993	-1923.492	-674.821	-1590.813	-6029.522	-3034.656	-1091.023	-2756.112	-441.124	-180.718
Lnalpha	-1.120***	-1.728***	-1.530***	-0.947***	0.815***	0.065	0.223	1.372***		
Cluster	364	158	66	221	364	158	66	221	156	65
Observations	2162	938	393	1303	2162	938	393	1303	926	387

Note: Marginal effects are calculated following eq. (4) and eq. (5) at the sample mean. Standard errors in parentheses. Subject dummies not presented.
*** $p<0.01$, ** $p<0.05$, * $p<0.1$

Table A1: List of Universities

University Name	**Academics**	**Region**
Brunel University	48	London
City University	23	London
Queen Mary University	31	London
University of Reading	22	South East
University of Cambridge	123	East
University of Essex	26	East
University of Leicester	29	East Midlands
Loughborough University	123	East Midlands
University of Durham	21	North East
Lancaster University	10	North West
University of Sheffield	100	Yorkshire
University of Edinburgh	54	Scotland
University of Glasgow	63	Scotland
University of Strathclyde	97	Scotland
University of Swansea	46	Wales
Total	**809**[*]	

[*] Academics can change university within the sample. Therefore, numbers do not add up to 809.

Table A2: Variable means by type of academic

	(1) traditional	**(2) hybrid**	**(2) commercial**	**(4) other**
Observations	2162	938	393	1303
Researcher IDs	364	158	66	221
Productivity measures				
PUBLICATIONS_{it}	2.02	3.61	2.64	1.43
CITATIONS_{it}	7.22	10.59	8.55	6.10
Patent measure				
PATENT_{it}	0.00	0.22	0.22	0.00
$\text{PATENT\_NUMBER}_{it}$	0.00	0.30	0.31	0.00
Funding measures (in 100,000 GBP)				
FUNDING_{it-1}	0.29	0.61	0.23	0.17
$\text{PUBLIC\_FUNDING}_{it-1}$	0.25	0.46	0.19	0.15
$\text{INDUSTRY\_FUNDING}_{it-1}$	0.04	0.15	0.04	0.02
RC_FUNDING_{it-1}	0.20	0.35	0.15	0.11
EU_FUNDING_{it-1}	0.03	0.07	0.01	0.02
$\text{GOV\_FUNDING}_{it-1}$	0.02	0.04	0.03	0.01
Individual characteristics				
PROFESSOR_{it-1}	0.34	0.50	0.38	0.22
FEMALE_{i}	0.06	0.05	0.08	0.09
NO_PHD_{i}	0.07	0.03	0.01	0.12
PHD_AGE_{i}	18.10	20.04	19.88	18.00
BIO_{i}	0.05	0.11	0.08	0.09
PHYSICS_{i}	0.10	0.14	0.27	0.20
MECHANICAL_{i}	0.18	0.08	0.05	0.11
ELECTRICAL_{i}	0.21	0.34	0.32	0.12
CHEMICAL_{i}	0.13	0.15	0.21	0.15
CIVIL_{i}	0.26	0.15	0.06	0.20

Table A3: Effects of external funding on publication outcomes by type of funding source

	1		2		3	
VARIABLES	PUBLICATIONS$_{it}$ NBREG		CITATIONS$_{it}$ NBREG		PATENTit LOGIT	
	dy/dx	SE	dy/dx	SE	dy/dx	SE
INDUSTRY_FUNDING$_{it-1}$	0.197*	(0.118)	-0.942*	(0.535)	-0.005	(0.013)
INDUSTRY_FUNDING$_{it-1}^{2}$	-0.359***	(0.085)	-0.046	(0.363)	0.017	(0.011)
RC_FUNDING$_{it-1}$	0.118***	(0.063)	0.058	(0.269)	0.009	(0.008)
RC_FUNDING$_{it-1}^{2}$	-0.079***	(0.030)	-0.005	(0.122)	-0.003	(0.005)
EU_FUNDING$_{it-1}$	0.228	(0.277)	3.784***	(1.317)	0.016	(0.029)
EU_FUNDING$_{it-1}^{2}$	-0.259	(0.725)	-7.945***	(2.616)	-0.074	(0.088)
GOV_FUNDING$_{it-1}$	0.161	(0.379)	4.175*	(2.327)	-0.045	(0.040)
GOV_FUNDING$_{it-1}^{2}$	-0.525	(1.018)	-9.382	(6.059)	0.101	(0.068)
PATENT $_{it-1}$	0.103	(0.070)	-0.326	(0.384)		
PUBLICATIONS $_{it-1}$					0.002*	(0.001)
PROFESSOR$_{it-1}$	0.954***	(0.138)	3.040***	(0.533)	0.017*	(0.010)
FEMALE$_{i}$	-0.141	(0.202)	-1.130	(1.077)	-0.018	(0.017)
NO_PHD$_{i}$	-1.920***	(0.369)	-6.241***	(1.745)	-0.059**	(0.028)
PHD_AGE$_{it}$	-0.043***	(0.007)	-0.134***	(0.032)	-0.001**	(0.000)
ln[Pub_Mean]|ln[Cit_Mean]|ln[Pat_Mean]	0.781***	(0.081)	1.257***	(0.251)	0.010	(0.009)
[Pub_Mean=0]|[Cit_Mean=0]|[Pat_Mean=0]	-1.528***	(0.231)	-1.890**	(0.934)	-0.047***	(0.012)
Pub_Stock|Cit_Stock|Pat_Stock	0.074***	(0.013)	0.056***	(0.011)	0.022***	(0.004)
Joint sign. of university dummies χ2 (14)	117.65***		102.61***		20.59*	
Joint sign. of subject dummies χ2 (5)	31.51***		33.34***		21.47***	
Joint sign. of year dummies χ2 (5)	12.32**		44.04***		15.77***	
Log-likelihood	-8058.676		-13248.694		-886.576	
Lnalpha	-1.032***	(0.070)	0.843***	(0.049)		
Cluster	809		809		787	
Observations	4796		4796		4667	

Note: Marginal effects are reported. Robust clustered standard errors in parentheses; clustered by individual researcher.
*** p<0.01, ** p<0.05, * p<0.1

Figure

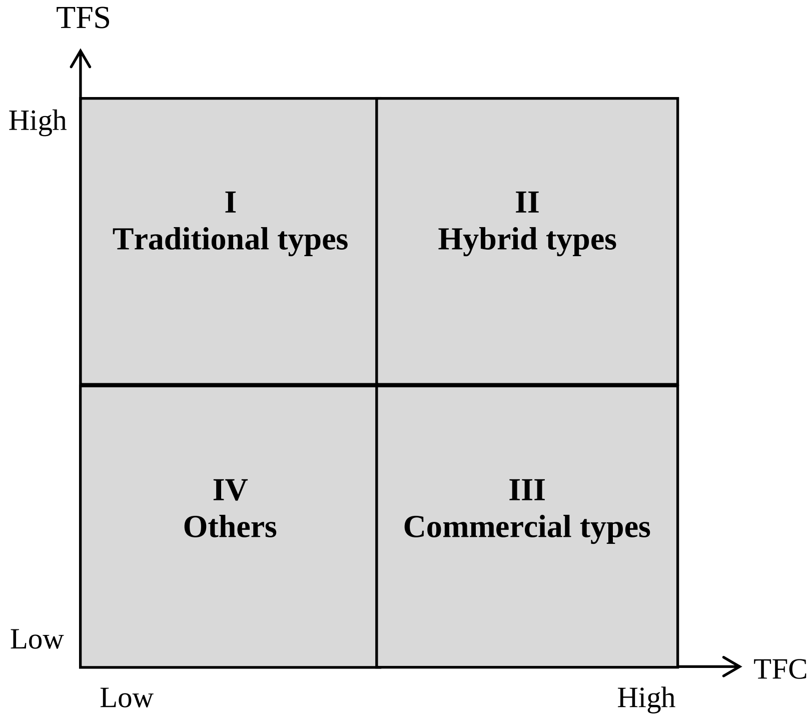

Figure 1: Classification of academics by their "Taste for Science" (TFS) and "Taste for Commercialization" (TFC)

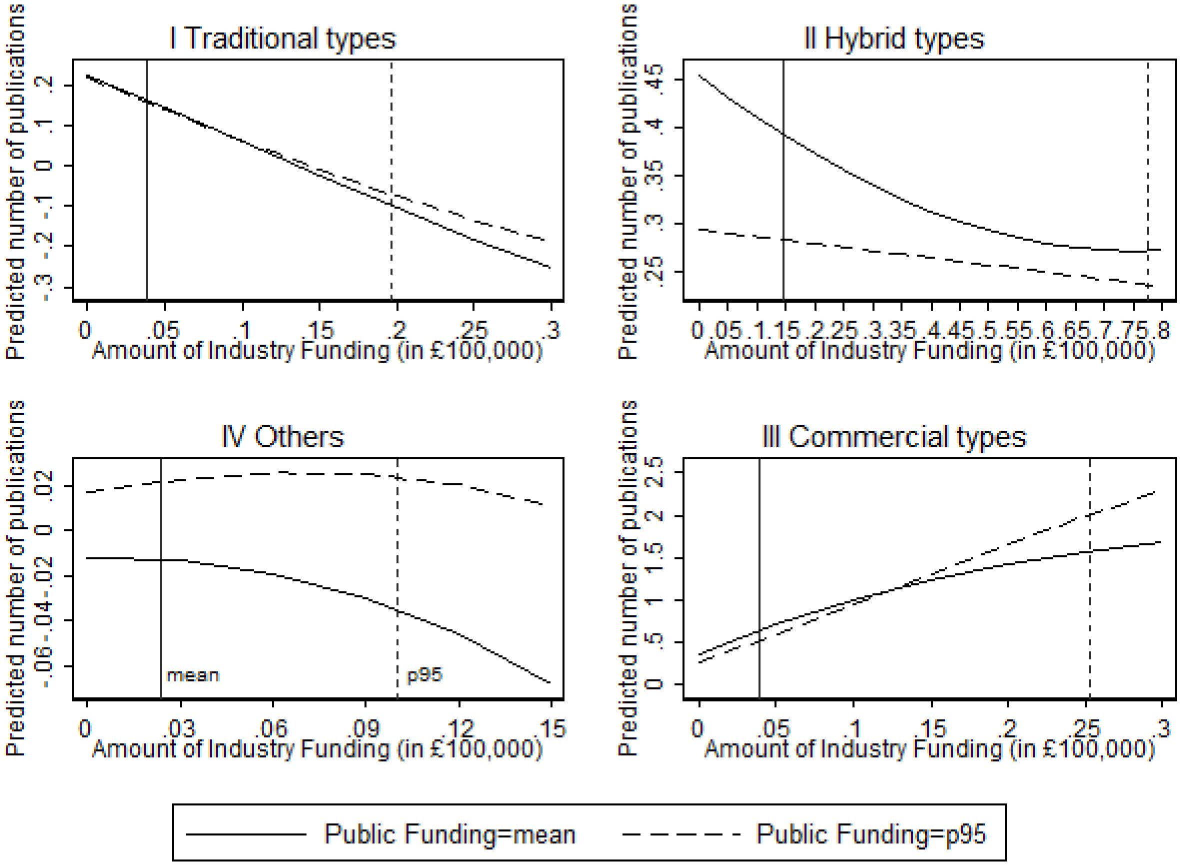

Figure 2: Effect of industry funding on the marginal effect of public funding on publication numbers (by type of academic)