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# WHAT'S THE PRICE OF CONSULTING? EFFECTS OF PUBLIC AND PRIVATE SECTOR CONSULTING ON ACADEMIC RESEARCH

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# What's the price of consulting? Effects of public and private sector consulting on academic research*


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**ABSTRACT**

Academic consulting is recognised as an important and effective means of knowledge transfer with the public and private sectors. These interactions with external sectors offer opportunities for research application but also raise concerns over their potentially negative consequences for academic research and its dissemination. For a sample of social, natural and engineering science academics in Germany, we find consulting to be widespread, undertaken by academics at all seniority levels and in all disciplines, with academics in the social sciences more likely to provide advice to the public sector and those in engineering to the private sector. Controlling for the selection into consulting, we then investigate its effect on research performance. While previous research suggested that consulting activities might come at the cost of reduced research output, our analysis does not confirm this concern. The results, however, suggest that stronger engagement in consulting increases the probability to cease publishing research altogether. This may point to a flight of consulting-active academics from active research. Moreover, public sector consulting comes with lower average citations which may suggest a move towards context-specific publications that attract fewer citations. We draw lessons for research institutions and policy about the promotion of academic consulting.



**KEYWORDS**

academic consulting, university-industry interaction, science advice, knowledge transfer, research performance, exit from academia

**JEL CLASSIFICATION**

O31; O33; O38; I23



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# 1. Introduction

In light of the considerable government spending for universities and public research organizations (PROs) there is a natural political and scientific interest in the design and effectiveness of knowledge and technology transfer mechanisms that affect economic payoffs from such public investments (OECD, 2014). This study focuses on academic consulting as one channel for knowledge exchange. Academic consulting is at least as widespread among academics as other knowledge exchange mechanisms such as collaborative and contract research, patenting, and spinoff company formation (see Perkmann et al., 2013 for a review of the literature). It is usually defined as a form of professional advisory service performed by full-time researchers who apply their professional or scholarly expertise outside their academic institution, often – but not always – for financial compensation. Such activities involve providing advice, preparing reports, resolving problems as well as generating or testing new ideas (Perkmann and Walsh, 2008).

Academic consulting is also considered an important channel by the users of academic advice. For example, Cohen et al. (2002) report that 32% of surveyed US firms consider consulting an important mechanism to gain insights into academic research. This figure is higher than for other forms of knowledge transfer such as contract research, patents or personnel exchanges. In the case of public consulting, policy-makers take account of science advice through dedicated expert panels or the appointment of scientific advisors (OECD, 2015). A survey of more than 300 civil servants and politicians in Germany showed that more than 70% of users of academic knowledge consider expert reports and personal communication with academics as helpful or very helpful for their work, making consulting more important than academic publications (Haucap and Thomas, 2014).

Although academic consulting is amongst the most common and effective means of external engagement activities for academics, it has received comparably little attention in the literature and is still seen as a "largely under-documented and under-studied [activity] that raises ethical and resources allocation issues" (Amara et al., 2013). Sceptics argue that consulting or other forms of external engagement may distract academics from their primary roles of teaching and research. It may therefore reduce the quantity of research output, particularly if free dissemination is restricted through contracts, or that it may even undermine the norms of open science including mechanisms of cooperation among academics (Shibayama, 2015). It may also affect quality of research outputs through a re-direction of research towards more applied agendas (Boyer and Lewis, 1984; Buenstorf, 2009). Proponents, on the other hand, endorse academic consulting for knowledge and technology transfer purposes, for new research ideas (e.g. Mansfield, 1995), revenue opportunities for the academic and their institution as well as for incentives to retain good scientists at the university or PRO (Buenstorf, 2009).

Although academic consulting has been studied in different institutional environments (e.g. Link et al., 2007; Jensen et al., 2010; Perkmann, 2011; Rentocchini et al., 2014; Amara et al., 2013; D'Este et al., 2013), we still know little about how it relates to academic research outcomes and more specifically departure from academic work. While some studies find that industry consulting is more prevalent amongst institutions with top-ranked science and engineering academics (Perkmann et al., 2011), others find that lower-rated research departments, and in the case of public sector consulting in economics less research active academics, are more often engaged in consulting (D'Este and Perkmann, 2011; Haucap and Thomas, 2014). These diverging results suggest differences across disciplines and types of consulting and it seems crucial to take into account not only the selection into consulting activities, but also heterogeneity in consulting activity itself. Previous research, however, almost exclusively focused on consulting with the private sector despite public sector consulting constituting a significant channel of knowledge transfer (Amara et al., 2013, Haucap and Thomas, 2014), especially in the health and social sciences (Abreu and Grinevich, 2013).

This study contributes to prior research by investigating the effects of private and public sector consulting on academic research outcomes, i.e. publications in scientific journals. Using survey data as well as bibliometric indicators, we investigate these effects taking into account a large set of personal, institutional, and scientific attributes that explain an academic's engagement in consulting activities. Further, we study the effects of consulting on the probability of (temporarily) exiting from academic research. The study builds on data of academics in Germany in the social sciences and humanities, engineering, life science and natural sciences, employed at universities or PROs.

We make use of information on academics' time distributions regarding teaching, research, administration, and consulting in a usual workweek to identify the occurrence and intensity of different consulting activities. In the final sample of more than 900 academics 44% engage in some form of consulting confirming that consulting is relatively common. About 17% provide consulting only to the public sector, 13% only to the private sector, and 14% to both. Academics spend, on average, 5.3% of their time in consulting (12.2% among consulting-active ones). Results show that private sector consulting is more prevalent in science and engineering, and public sector consulting is most common in the social sciences. Moreover, while we find women to be less likely to provide consulting to the private sector, we observe no gender difference with regard to public sector consulting. Taking the selection into consulting activities into account, our analysis of research outcomes does not find lower ex-post scientific publication numbers, which suggests that consulting does not compromise the disclosure of research results through traditional dissemination channels. However, we observe a higher probability to exit from active research (zero subsequent publications). Moreover, consulting, especially to the public sector, is associated with lower average citations numbers, which may indicate a more applied or more user-oriented research focus of consulting academics.

# 2. Literature Review

## 2.1 Academics as consultants

Academic consulting is not a new phenomenon. Universities and PROs have traditionally been committed to providing their expertise to external institutions (Shimshoni, 1970; Krimsky, 2003; Stephan, 2012; Edwards, 2015). Its popularity stems mainly from its versatile, cost-effective, rapid, and selective knowledge transfer from universities and PROs to external sectors without extensive involvement of academic personnel and material resources (Klofsten and Jones-Evans, 2000). Perkmann et al.'s (2013) review of the literature shows that academics' involvement in private sector consulting is relatively high across countries ranging from 17% of academics who engage in consulting in a given year in Germany (Grimpe and Fier, 2010) up to 68% of researchers in Ireland who do so at least once during their career (Klofsten and Jones-Evans, 2000).

Academic consulting can vary in several dimensions, for example, it may differ considerably in terms of remuneration (fee-based, access to materials/data, or pro-bono), contractor (private or public), scope (time and resources) and formalisation (formal or informal). In this paper we are concerned with differences in terms of contractor, i.e. public vs. private sector consulting.

Private sector consulting has received much attention in the literature, and is typically discussed in the broader context of informal technology transfer (e.g. Klofsten and Jones-Evans, 2000; Link et al. 2007; Grimpe and Hussinger, 2013), university-industry interactions (e.g. Perkmann and Walsh, 2009), knowledge spillovers (e.g. Jensen et al., 2010), or university research funding through the private sector (Hottenrott and Thorwarth, 2011; Hottenrott and Lawson, 2014; Czarnitzki et al., 2015). Public sector consulting, on the other hand, has received little or no attention in the empirical literature, despite the importance of science for government policy (OECD, 2015). Public sector consulting provides the knowledge upon which policy can be based but also monitors policy and is a valuable corrective to lobbyists and politics (Jasanoff, 2007). It has mostly been discussed in the context of science-policy interactions and science advocacy (e.g. Jasanoff, 1990, 2007).

Private and public sector consulting differ not only in the sector they address. Abreu and Grinevich (2013) find in a survey of over 20,000 UK academics, that interactions with the public sector (which include consulting) are more widespread than interactions with the private sector (52% of respondents compared to 41%), especially in the health sciences, humanities and the social sciences and for women and older academics. Public sector engagement is therefore particularly relevant for groups that are less likely to engage with the private sector.

Subject and individual differences between different types of consulting also mean that existing findings regarding the drivers of academic consulting with industry may not be the same for public sector consulting. Moreover, the contractor (or recipient) of consulting may be important when studying the consequences of consulting activities across scientific fields and other individual characteristics.

## 2.2 Consulting and research outcomes

The impact of consulting activities on academic research outcomes including scientific publications, research agenda setting, collaborative research or probability to exit from academia is subject to intense public debate[1], but has been studied little so far. We identified five studies that explicitly explore the influence of consulting on research performance. All focus on consulting with industry but find mixed results. Rebne (1989), studying consulting amongst US academics, finds a positive relationship between consulting activity and research productivity at low to moderate levels for all disciplinary groups except the humanities. Similarly, Mitchell and Rebne (1995) conclude that moderate amounts of consulting (up to four hours per week) generally facilitate researchers' productivity. More recently, Manjarres et al., (2008, 2009) and Rentocchini et al. (2014) find a negative effect of consulting on ISI-publications if a considerable amount of income is generated through consulting in the case of academics in Spain. However, Rentocchini et al. (2014) also point to field differences, showing that the negative effects occur in science and engineering but not in social sciences and humanities. The influence of public sector consulting, which may be more relevant in the social sciences and humanities, has not yet been examined separately.

[1] See, for instance, Erk and Schmidt (2014) or OECD (2015).

A closely related stream of research that may help to define expectations regarding the effect of consulting, involves studies looking at the effect of collaborative and contract research income on research productivity. Especially sponsorship from the private sector may include income from consulting projects with firms and therefore indirectly reflect an academic's engagement in consulting activities. In addition, consulting and contract research for industry are highly correlated (Gulbrandsen and Smeby, 2005; Ponomariov and Boardman, 2008), and a substantial number of university research projects are initiated through consulting (Mansfield, 1995). While some of these studies find positive correlations between research income from industry and research performance (Gulbrandsen and Smeby, 2005; Van Looy et al., 2006; Thursby et al., 2007), others point to a potential brain drain leading to fewer publications or fewer citations per paper (Hottenrott and Thorwarth, 2011, Banal-Estañol et al., 2015). In the case of public sponsors, studies have also found a negative effect for government agency funding. For example, Goldfarb (2008) finds that academics repeatedly funded by NASA experience a reduction of their research output. Several studies conclude that a lower publication output of sponsored academics may be explained by delay and secrecy (Blumenthal et al, 1996; Florida and Cohen, 1999; Krimsky, 2003; Czarnitzki et al., 2015) or sponsors' impact on research agendas (Etzkowitz and Webster, 1998; Vavakova, 1998; Geuna, 2001; Hottenrott and Lawson, 2014). In addition, the provision of consulting and advice especially in the public sector requires the preparation of reviews and commissioned reports that result in 'grey literature' rather than in scientific journal publications (Salter, 1988; Jasanoff, 1990). The existing evidence thus suggests that we may expect negative effects on publication outcomes if more time is spent on consulting, regardless of the type of partner.

Finally, researchers may leave academic research to engage full time in other occupations including consulting, board services or spin-off creation. Especially the latter has been shown to reduce long-run publication output (Czarnitzki and Toole, 2010; Toole and Czarnitzki 2010), whereas the influence of consulting on exit from publishing academic research has not been addressed in previous work. Existing literature has generally attributed the probability to exit to low publication performance and patenting (Zucker et al., 2002; Roach and Sauermann 2012; Balsmeier and Pellens, 2014), to the role of labour market conditions that affect the attractiveness of the private sector compared to the academic one (Stephan and Levin 1992; Geuna and Shibayama, 2015), as well as to gender and family situation (Kahn, 1993; Ginther and Kahn, 2004; Wolfinger et al., 2009; Mairesse and Pezzoni, 2015). However, the activities that academics' engage in within their workplace, including consulting, may affect researchers' preferences and opportunities for academic research compared to private sector and administrative or advisory work. Hottenrott and Lawson (2015) show, for instance, that university departments that engage in contract research with industry are more likely to see departing academics move to the private sector or to non-research work within the public sector. In the case of public sector consulting academics may be called on to serve on expert committees and, in the case of PROs, have an obligation to provide policy advice as part of their job (OECD, 2015). The skills required for these services differ from those required for scientific work and not all academics will be equipped to take up these tasks (Salter, 1988). A selected set of academics may therefore take on the role of brokers or full time consultants, no longer concerned with their scientific research (Haucap and Moedl, 2013). This kind of exit from publishing would only be possible for tenured academic staff. To conclude, consulting may be conducive to a move out of academia or the take-up of more administrative or advisory posts within the university or research institute, activities that would not result in publications in academic journals. Public consulting is expected to affect the exit of senior academic staff, while private sector consulting may be more likely to result in the exit of those in more junior positions.

# 3. Data and model specification

The examination of academics' consultancy activities in section two suggested some expectations regarding their research outcomes and (temporary) exit from research. It also suggested that the selection into consulting does not occur at random but that a series of individual and institutional characteristics are determining this selection. The objective of the following analysis is thus to study the impact of consulting on research outcomes and (temporary) exit from research taking into account those individual, institutional, scientific, and commercial characteristics that drive consulting engagement. The proposed analysis therefore proceeds in a two-stage framework where we estimate the probability of (temporary) exit and the publication performance of academics while accounting for their selection into consulting.

## 3.1 Data

The following analysis builds on data from an online survey of academics in Germany at both, universities and non-university research institutions.[2] The survey was conducted by the Centre

[2] Higher education institutions as well as public research organisations (PROs) play an important role in the German academic research landscape. PROs include the Fraunhofer and Max-Planck Society, as well as the

for European Economic Research (ZEW) in 2008 and targeted academics at universities or public research institutions in the humanities and social sciences, engineering, life science and natural sciences. Survey questions referred to the pre-survey period from 2002 to 2008 or to the current year. We complement the survey data with publication data from ISI web of knowledge. In particular, we performed text field searches on the academics' names in the publication database (articles, books, reviews, proceedings) and manually screened matches based on CV and website information. Further, we searched the Espace database of the European Patent Office and the database of German Patent Office for patents on which the academics appear as inventor. As in the case of publications, all matches had been manually checked which yielded a publication and patent record for all individual academics from their first data base entry until 2013 and citations to their publications until autumn 2015.[3] We limit the pre-sample publication window to the years 2002 to 2008 to have the same pre-survey observation window for all academics, which also accounts for different levels of seniority. Removing observations with incomplete records, the final sample comprises 951 individual-level observations. Table 1 reports descriptive statistics for all the variables used in the regression (for pairwise correlations see Table A.1).

**Dependent variables**

The main variables of interest are the performance of academics in the post-survey period (2009-2013) and their (temporary) exit from academia. We consider the exit from research work to be reflected in zero ISI publications in the post-survey period (2009 to end 2013) (*exit*). This variable thus reflects research inactivity over that period and not necessarily the termination of a work contract. About 14% of academics stop publication in the post-survey period. The average number of *publications* is 12 and each publication receives 12 citations (*average citations*) in the time window considered.[4] From the individual publication and citation counts, we further derive field-weighted counts to account for heterogeneous publication/citation patterns of each discipline (*field-weighted publications, field-weighted average citations*). A value below 1 represents a below field-average output and a value above 1 represents an above field-average output. As typical for publication and citation counts, the

Helmholtz- and Leibniz Associations and accounted for around 20% of acadmic staff in 2012 and for 34.4% of the European Research Council grants awarded to German institutions during the period 2007-2013 (DFG, 2015).

[3] We consider a citations window from publication until autumn 2015. The censoring of citations to newer articles should be of minor concern as most citation counts peak around 2 years (see Adams, 2005; Bouabid, 2011).

[4] That is the average number of citations per publication received in the citation window.

distributions are skewed with a median number of publications of about 6 and a field-weighted median of 0.53. The median number of citations per article is 8 in the post-survey period and the field-weighted average is 0.68.

**Consulting activities**

Our data is distinctive from previous studies in using the time-share that academics devote to consulting (*consulting share*).[5] The advantage of using survey-based time-shares as opposed to consulting income or official university records[6] is that academics have no incentives to under or over report their consultancy work and that we also capture consulting activities for which no financial compensation had been received. In doing so, we avoid problems in measuring consulting activities that arise if individuals are able to charge very different fees and thus have different levels of income per hour of consulting work. In addition, we are able to distinguish between consulting to the private (*private consulting share*) and the public sector (*public consulting share*).

**Controls**

For demographic, scientific, institutional and commercial data we utilise the survey as well as publication and patent histories of academics. Of the academics in the sample, 21% belong to *social sciences and humanities*, 30% to *life sciences* (biology, medicine, agriculture and veterinary sciences), 31% to the *natural sciences* (chemistry, physics, earth science and mathematics) and 19% are active in *engineering*. Academics are, on average, 49 years old (*age*), 71% head a research group (*group leader*) and 15% are *female*. The main ranks in German universities and PROs are *professor* (54%), *assistant professors* (11%, including academics working towards habilitation), *senior researcher* (26%) and *junior researcher* (10%, scientific assistance staff that do not hold and/or are studying for a PhD). More than half of the academics in the sample (59%) are employed at universities (*university*), while the remaining academics work at PROs or other research institutions. 10% of academics have *multiple affiliations,* i.e. report to be affiliated with a university and PRO. Additionally, the size of the local peer group, i.e. the number of people within the same institution working in closely

[5] The questionnaire asked: "Please give the percentage of working time you currently spend on the following activities." Respondents distributed time-shares over: research; research funded by research grants; teaching; administration; private sector consulting; public sector consulting. See Table A.2 for an overview of the division of time.

[6] While German law in principle requires research staff at universities and PROs to report additional consulting income to their employer, there are certain exemption levels that vary between different institutions below which no reporting is required (Hochschul-Nebentätigkeitsverordnung, HNtV). Thus, income information provided by institutions would not provide a full picture.

related fields (*peergroup size*) is measured.The survey further allows us to construct a measure for *collaborative reach* based on the location of research partners during the 2002 to 2008 period[7], and a measure for *international visibility* based on reported international conference participation during an average year. The survey also includes information on academics' grant-based research income from the European Union, national and regional governments, science foundations, such as the German Research foundations (DFG), industry and other external funders during the period 2002 to 2006. Funding was aggregated into two measures, *industry funding* and *public funding*. The mean values for external funding is 16 thousand euros for industry funding and 1.1 million euros for public funding which includes funding from the EU, governments, and scientific foundations.

The survey also includes extensive information on commercial activities undertaken. About 17% of academics had at least once been involved in starting a new firm (*firm*), 43% engaged in technology transfer and commercialisation activities with the private sector other than through consulting during the previous 12 months *(techtransfer industry)* and about 22% stated to have co-authored articles with employees from the private sector in the previous 12 months *(coauthorship industry).*

Survey data was complemented with pre-survey patent and publication data. The number of patents *(patents)* during the pre-survey period (from the first patent until 2008) is 1.1, on average, but much higher among patenting academics (about five). Academics published on average 12 items in the pre-survey period (between 2001 and 2008). The number of total citations per academic is 460, while half of the sample has fewer than 73 citations. Looking at the average number of citations per publication, we find a similar, but less skewed distribution (mean of 24 vs. median of 16).

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[7] The variable takes values from zero to five, where zero stands for 'no collaborative work', one for 'collaboration only within the home institution', two for 'collaboration only inside Germany', three for 'European-wide collaboration, but not beyond'. Categories four and five capture collaboration with North America and the rest of the world, respectively.

Table 1: Descriptive statistics

| Variable | unit | source | median | mean | s.d. | min. | max. |
|---|---|---|---|---|---|---|---|
| **Outcome Variables** | | | | | | | |
| $\text{exit}_{2009\text{-}2013}$ | count | Survey | 0 | 0.14 | 0.34 | 0 | 1 |
| $\text{publications}_{2009\text{-}2013}$ | count | Survey | 6 | 12.44 | 20.13 | 0 | 278 |
| $\text{citations}_{2009\text{-}2013}$ | count | Survey | 53 | 233.15 | 602.90 | 0 | 10088 |
| av. $\text{citations}_{2009\text{-}2013}$ | fraction | Survey | 8.44 | 11.85 | 15.82 | 0 | 157.67 |
| field-weighted $\text{publications}_{2009\text{-}2013}$ | fraction | Survey | 0.53 | 1 | 1.57 | 0 | 16.93 |
| field-weighted av. $\text{citations}_{2009\text{-}2013}$ | fraction | Survey | 0.68 | 1 | 1.57 | 0 | 23.14 |
| **Consulting activities** | | | | | | | |
| consulting | binary | Survey | 0 | 0.44 | 0.50 | 0 | 1 |
| public consulting | binary | Survey | 0 | 0.31 | 0.46 | 0 | 1 |
| private consulting | binary | Survey | 0 | 0.27 | 0.44 | 0 | 1 |
| consulting share | percentage | Survey | 0 | 5.31 | 10.27 | 0 | 100 |
| public consulting share | percentage | Survey | 0 | 3.06 | 7.96 | 0 | 100 |
| private consulting share | percentage | Survey | 0 | 2.25 | 6.23 | 0 | 100 |
| **Personal attributes** | | | | | | | |
| age | count | Survey | 49 | 49.40 | 8.28 | 28 | 74 |
| female | binary | Survey | 0 | 0.15 | 0.36 | 0 | 1 |
| junior researcher | binary | Survey | 0 | 0.09 | 0.29 | 0 | 1 |
| senior researcher | binary | Survey | 0 | 0.26 | 0.44 | 0 | 1 |
| assistant professor | binary | Survey | 0 | 0.11 | 0.32 | 0 | 1 |
| full professor | binary | Survey | 1 | 0.54 | 0.50 | 0 | 1 |
| group leader | binary | Survey | 1 | 0.71 | 0.45 | 0 | 1 |
| **Scientific attributes** | | | | | | | |
| $\text{publications}_{2002\text{-}2008}$ | count | ISI WoS | 4 | 11.70 | 21.03 | 0 | 305 |
| $\text{citations}_{2002\text{-}2008}$ | count | ISI WoS | 73 | 460.02 | 1141.92 | 0 | 16910 |
| average $\text{citations}_{2002\text{-}2008}$ | fraction | ISI WoS | 16.13 | 24.18 | 31.67 | 0 | 344.2 |
| field-weighted $\text{publications}_{2002\text{-}2008}$ | fraction | ISI WoS | 0.47 | 1 | 1.81 | 0 | 24.52 |
| field-weighted average $\text{citations}_{2002\text{-}2008}$ | fraction | ISI WoS | 0.69 | 1 | 1.39 | 0 | 17.18 |
| collaborative $\text{reach}_{2002\text{-}2008}$ | ordinal | Survey | 3 | 3.06 | 1.36 | 0 | 5 |
| international visibility | fraction | Survey | 0.71 | 0.69 | 0.17 | 0 | 1 |
| industry $\text{funding}_{2002\text{-}2006}$ | amount | Survey | 0 | 0.16 | 0.46 | 0 | 11 |
| public $\text{funding}_{2002\text{-}2006}$ | amount | Survey | 0.40 | 1.10 | 3.03 | 0 | 75 |
| **Institutional attributes** | | | | | | | |
| peergroup size | count | Survey | 10 | 39.46 | 148.47 | 0 | 3000 |
| university | binary | Survey | 1 | 0.59 | 0.49 | 0 | 1 |
| multiple affiliation | binary | Survey | 0 | 0.10 | 0.31 | 0 | 1 |
| social sciences | binary | Survey | 0 | 0.21 | 0.41 | 0 | 1 |
| life sciences | binary | Survey | 0 | 0.30 | 0.46 | 0 | 1 |
| natural sciences | binary | Survey | 0 | 0.31 | 0.46 | 0 | 1 |
| Engineering | binary | Survey | 0 | 0.19 | 0.39 | 0 | 1 |
| **Commercial attributes** | | | | | | | |
| $\text{patents}_{\text{pre2009}}$ | count | EPO/DPMA | 0 | 1.06 | 3.72 | 0 | 41 |
| firm | binary | Survey | 0 | 0.17 | 0.38 | 0 | 1 |
| techtransfer industry | binary | Survey | 0 | 0.43 | 0.50 | 0 | 1 |
| coauthorship industry | binary | Survey | 0 | 0.22 | 0.41 | 0 | 1 |

Notes: Number of observations = 951. Funding variables in 100.000€. There are two individuals with consulting shares of 100%, one for each type of consulting. Both are project leaders so that the answer seem indeed realistic and no measurement error. The reference period for the citation variables (for instance 2009-2013 or 2002-2008) refers to publication in that period and the citations received by these publications until 2015.

## 3.2 Consulting-active versus consulting-inactive academics

Table 1 shows that in a typical week academics spend roughly 5.3% of their time on consulting. Among consulting-active academics the average time spent on consulting is 12.2%. About 50% is spent on research, and 21% on each teaching and administration (see Table A.2 for more details on the time distributions). While the overall time share devoted to academic consulting is not high, 44% of academics do at least some consulting. About 27% of academics consult private sector companies and 31% public institutions; 14% engage in both types of consulting. Table A.2 also shows differences in time distributions between consulting active and inactive academics. While the former spend significantly less time on research (30% versus 34%) and particularly less time on grant-based research (17% versus 23%), teaching loads differ only slightly (20% versus 23%) and administrative duties are similar (both 21%). These numbers suggest that consulting may substitute research financed through grants, but is not associated with a higher administrative burden or less time devoted to teaching.

Certain attributes differ considerably between those who are consulting-active and those that are not. Table 2 compares the mean values of the dependent variables (publications, citations and exit), and gender, academic rank and discipline based on consulting status.

The share of *exits* is distinctly higher among public sector consultants with about 19% compared to the group of non-consultants with 12% exits. Interestingly, exit is lowest in the group of academics who consult both the private and the public sector (11%). Table A.4 shows exit frequencies by field and rank. In terms of publication numbers in the post survey period, our data suggests that academics who do both types of consulting publish significantly more, but the average number of citations per paper published during that period is significantly lower for consulting-active academics and especially those that provide consulting to the public sector. However, the field-weighted average number of citations show no significant differences.

In our sample academics engaged in consulting are more often full professors. This is due to professors being the largest group within the sample. Table A.3 also reports the share of respondents engaged in consulting by rank and disciplinary field. There we see that assistant professors are the group where consulting is least wide-spread. Amongst professors and junior researchers consulting with the public sector is slightly more common than with the private sector. Table 2 further shows that female academics are less likely to do private sector consulting, but not less likely than men to engage in public consulting. We further observe that in the social sciences and humanities, “public sector only” consulting is more prevalent than private sector consulting or no consulting, while in life and natural sciences the differences are less pronounced. In natural sciences we see the overall lowest involvement in consulting. In engineering we see for a much larger involvement in consulting with the private sector, reported by almost 50% of academics (see Table A.3 for the share of consulting-active academics by discipline and A.2 for consulting time shares by discipline).

Table 2: Descriptive statistics by type of consulting (selected variables)

| | Consulting active | Only public sector consulting | Only private sector consulting | Public and private sector consulting | I. vs V. | II. vs. V. | III. vs V. | IV. vs. V. | No consulting |
|---|---|---|---|---|---|---|---|---|---|
| | I. | II. | III. | IV. | | | | | V. |
| Observations | 414 | 159 | 122 | 133 | | | | | 537 |
| | mean (sd) | mean (sd) | mean (sd) | mean (sd) | t-test | | | | mean (sd) |
| **Outcome variables** | | | | | | | | | |
| exit$_{2009\text{-}2013}$ | .15 (.36) | .19 (.40) | .14 (.35) | .11 (.31) | | ** | | | .12 (.33) |
| publications$_{2009\text{-}2013}$ | 13.88 (22.90) | 11.19 (20.37) | 14.58 (24.48) | 16.44 (24.07) | * | | * | *** | 11.33 (17.63) |
| citations$_{2009\text{-}2013}$ | 258.66 (643.08) | 216.03 (669.58) | 295.32 (726.59) | 276.00 (519.26) | | | | | 213.49 (569.81) |
| av. citations$_{2009\text{-}2013}$ | 10.71 (14.11) | 9.60 (12.80) | 12.59 (18.37) | 10.33 (10.61) | * | ** | | | 12.72 (16.99) |
| field-weighted publications$_{2009\text{-}2013}$ | 1.15 (1.73) | .98 (1.72) | 1.18 (1.69) | 1.32 (1.76) | *** | | ** | *** | .88 (1.44) |
| field-weighted av. citations$_{2009\text{-}2013}$ | .99 (1.65) | .95 (1.61) | 1.16 (2.20) | .88 (.98) | | | | | 1.01 (1.51) |
| **Controls** | | | | | | | | | |
| female | .13 (.34) | .21 (.41) | .07 (.25) | .10 (.30) | | | *** | * | .16 (.37) |
| junior researcher | .08 (.27) | .11 (.32) | .07 (.25) | .06 (.24) | | | | | .10 (.31) |
| senior researcher | .25 (.43) | .22 (.42) | .34 (.47) | .20 (.40) | | | * | | .26 (.44) |
| assistant professor | .06 (.24) | .08 (.27) | .07 (.25) | .03 (.17) | *** | ** | ** | *** | .15 (.36) |
| full professor | .61 (.49) | .58 (.49) | .53 (.50) | .71 (.46) | *** | ** | | *** | .48 (.50) |
| social sciences | .23 (.42) | .37 (.48) | .15 (.36) | .14 (.34) | | *** | | | .19 (.40) |
| life sciences | .32 (.47) | .33 (.47) | .28 (.45) | .33 (.47) | | | | | .28 (.45) |
| natural sciences | .21 (.41) | .21 (.41) | .19 (.39) | .23 (.42) | *** | *** | *** | *** | .38 (.49) |
| engineering | .24 (.43) | .09 (.28) | .39 (.49) | .30 (.46) | *** | * | *** | *** | .14 (.35) |

Note: *** (**,*) indicate a significance level of 1% (5%, 10%). For the reference period for the variables see Table 1.
[a] Variables used in the first stage equation only (selection into consulting)

## 3.3 Estimation Strategy

We estimate the probability of exit and the publication performance while accounting for selection into consulting. Several previous studies stress the relevance of personal and institutional attributes in explaining academic consulting, characteristics, which are included in the first stage of the selection model, here. The selection into consulting is estimated for each academic $i$:

$$\Pr(Consulting_i) = \beta_0 + \beta_1\, Pers_i + \beta_2\, Inst_i + \beta_3\, Scien_i + \beta_4\, Comm_i + u_i \qquad (1)$$

With the vector *Pers* comprising personal attributes of academics such as age, gender dummy and occupational rank. *Scien* consists of the log of publications, citations, collaborative reach and international visibility as well as the (logged) amounts of grant-based research income. The vector *Inst* includes institutional measures such as group leader, university affiliation, peer group size, multiple affiliation and the scientific field. Finally, the vector *Comm* contains the log of patents, firm creation as well as technology transfer and co-authorship with industry. Parameter $u$ is the error term. In addition, we estimate simultaneous equation models (see de Luca, 2008) to account for the interdependence between and co-occurrence of private sector and public sector consulting.

Second, we estimate the probability of exit from academic research while accounting for the first stage selection into consulting (as specified in equ. 1). We also account for the possibility of retirement and check the sensitivity of the results to the exclusion of individuals who were 64 years or older at the time of the survey. Thus, we model the exit probability [conditional on the first stage, equation (1)] as follows:

$$\Pr(Exit_i) = \gamma_0 + \gamma_1\, Consulting\ share_i + \gamma_2\, Consulting\ share_i^2 + \gamma_3\, Controls_i + u_i \qquad (2)$$

We first estimate a model without distinguishing between the contractors. Second, we specify a model in which we explicitly distinguish time devoted to public sector versus private sector consulting. The second order term is included to account for possible non-linear effects. The vector *Controls* includes the academics' age, a gender dummy, a university dummy, field-weighted publications and field-weighted average citations in the pre-sample period, patents, grant-based research funding, scientific field and rank dummies. The two-stage model is identified through a set of exclusion restrictions (firm foundation experience, tech-transfer activities with industry, group leadership and multiple affiliation) which enter the first stage equation significantly, but are insignificant and therefore excluded in the second stage.

Next, we estimate linear endogenous switching models (see Lokshin and Sajaia, 2004) that also account for the non-randomness of consulting activity in the effect of consulting on post-survey publication performance, but additionally estimate outcome equation for both groups, i.e. provide a publication outcome equation also for consulting inactive academics. That is, the relationship between consulting and the number of publications *(publications$_{2009\text{-}2013}$)* and the average number of citations per publication (*average citations$_{2009\text{-}2013}$*) will be estimated conditional on the engagement in consulting and thereby accounting for path dependency of consulting activities on previous research performance. We estimate separate models for consulting in general and the two types of consulting, and for the different publication-based outcome variables:

$$Outcome_i = \gamma_0 + \gamma_1\, Consulting\ share_i + \gamma_2\, Consulting\ share_i^2 + \gamma_3 Controls + u_i \qquad (3)$$

The first-stage equation is specified according to equation (1) and the outcome equation is estimated via maximum likelihood method. We employ logged publication and average citation numbers to account for the skew in the distribution and for convenient interpretation of the coefficients. The vector of control variables and the set of exclusion restrictions corresponds to the exit models. We include the log of an academic's pre-sample publication performance[8] in the equation to capture i) path dependency and cumulative advantage effects in publication numbers and ii) the otherwise unobserved ability to publish of an individual academic. These initial productivity variables thus proxy for permanent individual unobservable effects, or "fixed" effects, which are not directly observable, but associated with underlying variables including as individual capability, motivation and talent (Mairesse and Pezzoni, 2015) similar to the specification proposed by Blundell et al. (1995, 2002) for count data.

[8] The pre-sample variables are adjusted to the respective dependent variable, i.e. based on field-weighted publication counts if the dependent variable is ln(publications) and average citations in the model for ln(av. citations).

# 4. Results

Table 3 shows the results (marginal effects) from the set of probit models that represent the first stage equation, the probability of engaging in any consulting (model 1), and results from simultaneous probit models on public consulting and/or private sector consulting (model 2).

We find that older academics are more likely to engage in consulting, but the effect of age is twice as high for consulting with the public sector compared to the private sector. Professors and junior researchers are more likely to engage in consulting than mid-career academics. These results for age and academic rank support prior research on industry consulting. Louis et al. (1989) and Rentocchini et al. (2014) observed a positive correlation with academics' age and several studies find tenured faculty to be more likely to engage in (paid) consulting (Link et al., 2007; Boardman and Ponomariov, 2009; Amara et al., 2013). In addition we see that junior academics are also more likely to engage in consulting, perhaps due to their engagement in research funded teams involving more senior leaders. Similar findings were reported in Amara et al (2013) who show that research staff and full professors are more likely to engage in paid consulting than mid-career academics.

We further find that women are less likely to engage in consulting than men, but that this effect is driven by private sector consulting. There is a positive, albeit insignificant, correlation for women regarding public sector consulting. This confirms Abreu and Grinevich (2013), who find that while women are less likely to interact with the private sector compared to men, they are more likely to engage with the public sector. The findings are also in line with prior research on industry consulting that consistently showed lower activity for women (e.g. Link et al., 2007; Grimpe and Fier, 2010).

In terms of scientific attributes, we see that pre-survey field-weighted average citations are negatively correlated with consulting, whereas publication counts show a positive relation. In the estimation that differs between public and private consulting we see that average citations correlate negatively with public consulting while they do not significantly explain private sector consulting. The lower citation count may indicate that these academics produce more user-oriented or context-specific research more suited to consulting activity. Our findings also provide an explanation for the mixed results in the prior literature suggesting that highly productive but lower quality academics are more consulting active.

Funding and grant acquisition does not predict consulting in model 1. However, model 2 shows that while industry funding correlates strongly and positively with private sector consulting it correlates negatively with public sector consulting. The contrary is the case for public funding. This corroborates prior research. For example, D'Este et al. (2013) previously found contract funding from industry to have a positive effect on the amount received through consulting. Amara et al. (2013) also confirm a positive industry funding effect for paid consulting and unpaid industry consulting but not for public consulting.

The findings further show that collaborative reach correlates positively with consulting probability, but that this effect is driven by public sector consulting. International visibility has a positive effect for private sector consulting only. Group leaders have a higher probability of engaging in consulting, but again the effect stems from public sector consulting. The local peer group size is negatively associated with consulting, suggesting that academics working in small teams are more likely to look for external consulting options. University academics are less likely to engage in consulting compared to academics at PROs. The higher propensity for consulting at non-university research centres may be due to differences in research organisation at institutions that have no teaching obligations compared to those that provide education. This negative effect is counterbalanced by research centre membership for those academics that are affiliated to both types of institutions, but only in the case of public sector consulting.

In terms of scientific disciplines, we find that the humanities and social sciences are more active in public consulting than science and engineering, while private sector consulting is slightly higher in life sciences and engineering. This confirms findings by Abreu and Grinevich (2013) in the UK context who also find that public sector interactions are more wide-spread in the social sciences and private sector interactions in science and engineering.

Not surprisingly, other commercial attributes regarding technology transfer to and co-authorship with industry correlate positively with private sector consulting. This confirms prior findings in the field. For example, Louis et al. (1989) were among the first to point out that entrepreneurial behaviours may predict any form of external relation (such as private sector consulting). In addition, Haeussler and Colyvas (2011) and Landry et al. (2010) find that industry consulting correlates with spin-off creation and other informal knowledge transfer activities to private businesses. Technology transfer also correlates with public sector consulting but to a smaller extent while patenting academics are less likely to engage in public consulting. Academics sceptical towards commercialisation in terms of patents may still favour other types of knowledge transfer, including consulting for public sector institutions.

The correlation between the public and private sector consulting equation is positive and significant, pointing to the importance of estimating these equations jointly.[9] It also indicates that academics make use of both engagement modes simultaneously.

Table 3: Results of probit and simultaneous probit models on private and public sector consulting

| Model | 1 | 2 | |
|---|---|---|---|
| Dependent variable | consulting | public consulting | private consulting |
| | df/dx (s.e.) | df/dx (s.e.) | df/dx (s.e.) |
| **Personal attributes** | | | |
| age | .004*** (.001) | .006*** (.001) | .002*** (.001) |
| female | -.008 (.025) | .039 (.038) | -.058*** (.020) |
| junior researcher | | Reference Category | |
| senior researcher | -.062*** (.022) | -.107*** (.016) | .015 (.017) |
| assistant professor | -.168*** (.042) | -.159*** (.023) | -.072** (.032) |
| full professor | .045 (.092) | -.017 (.072) | .074 (.053) |
| **Scientific attributes** | | | |
| field-weighted $publications_{2002-2008}$ | .007* (.004) | .006* (.004) | .010*** (.003) |
| field-weighted av. $citations_{2002-2008}$ | -.032*** (.010) | -.030*** (.004) | -.010 (.011) |
| industry $funding_{2002-2006}$ | .145 (.089) | -.083*** (.029) | .188*** (.062) |
| public $funding_{2002-2006}$ | .042 (.041) | .114*** (.017) | -.045*** (.015) |
| collaborative $reach_{2002-2008}$ | .016* (.009) | .033*** (.013) | -.001 (.008) |
| international visibility | .037 (.056) | -.011 (.050) | .094* (.054) |
| **Institutional attributes** | | | |
| group leader | .059 (.050) | .071*** (.023) | .005 (.039) |
| ln(peergroup size) | -.019** (.009) | -.022*** (.008) | -.010 (.010) |
| university | -.144*** (.056) | -.102* (.061) | -.056* (.029) |
| multiple affiliation | .159** (.076) | .199*** (.064) | .022 (.047) |
| social sciences | | Reference Category | |
| life sciences | -.110* (.061) | -.101* (.054) | .031* (.013) |
| natural sciences | -.263*** (.030) | -.198*** (.044) | -.058 (.044) |
| engineering | -.125*** (.045) | -.124*** (.031) | .065 (.068) |
| **Commercial attributes** | | | |
| $\ln(patents_{pre2009})$ | .009 (.029) | -.062*** (.016) | .017 (.015) |
| firm | .050*** (.017) | .050 (.039) | .068 (.043) |
| techtransfer industry | .241*** (.022) | .069*** (.015) | .309*** (.014) |
| coauthorship industry | .098* (.054) | .044 (.068) | .077* (.044) |
| Log pseudolikelihood | -559.40 | -918.80 | |
| rho | | .49*** (.04) | |

Number of observations: 951. Marginal effects at means. *** (**,*) indicate a significance level of 1% (5%, 10%). All models contain a constant. Robust standard errors in parenthesis. Standard errors clustered by academic rank.
If we include the unweighted publication and citation variables the sign and significance levels are similar.

[9] We also estimate simultaneous equation models on the time-shares devoted to public and private sector consulting. However, since the effects of the explanatory variables are very similar to the ones in the probit and the correlation coefficient between the time-share equations is insignificant, we refrain from showing these results in detail. The detailed estimation results are available upon request.

Accounting for selection into consulting we then estimate the propensity to exit from publishing, i.e. the likelihood of having zero publications in the post-survey period 2009-2013. Figure 1 depicts graphically the marginal effects of consulting on exit probability for academics below retirement age. We find that both types of consulting increase the likelihood of exit for most of the range of observed consulting time-shares, but the average marginal effect is larger for private sector consulting (0.002) compared to public sector consulting (0.001).

Figure 1: Predictive margins for "exit" (909 observations: age<65)

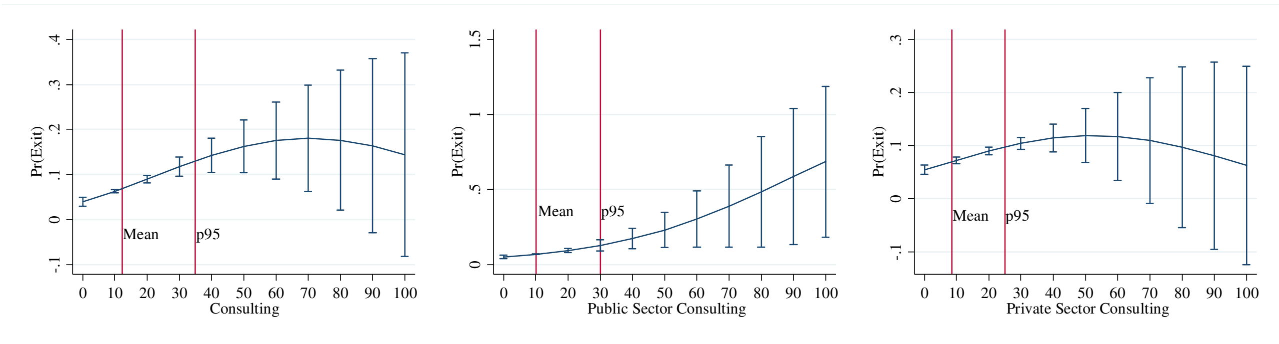
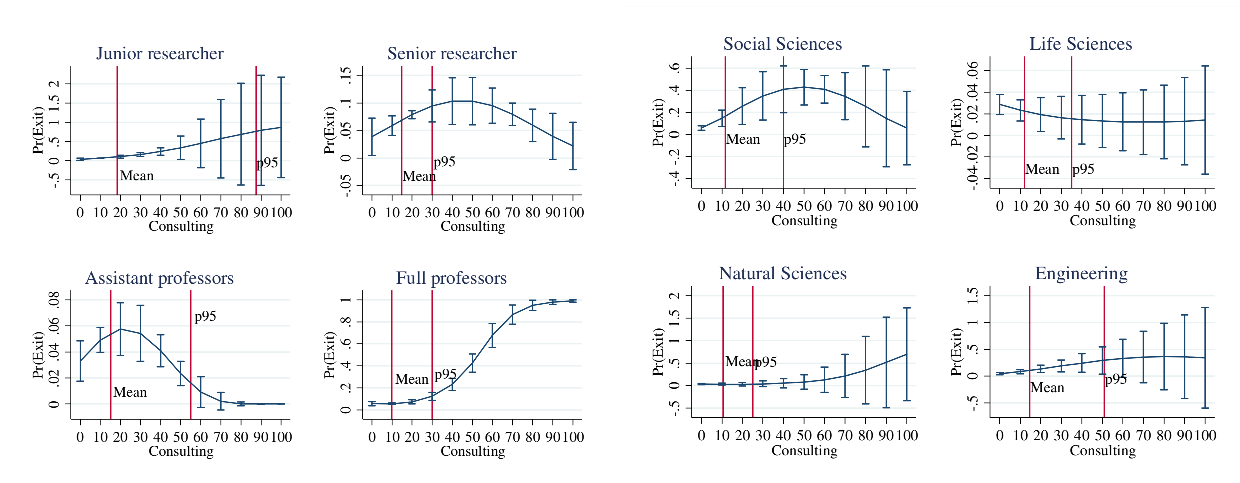
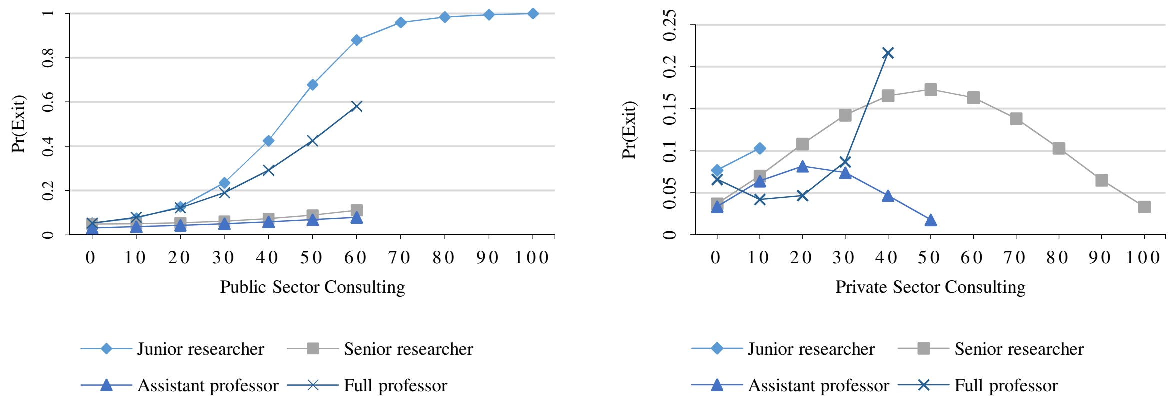



Figure 2: Predictive margins for "exit" by rank and field (909 observations: age<65)




When differentiating the consulting effects by academic rank we see that the exit probability increases with consulting intensity for junior researchers, senior researchers and full professors but less so for assistant professors (Figure 2). For full professors this is true for both public and to a lesser extent for private sector consulting. Exit of junior researchers is instead driven by public sector consulting only (Figure 3). Figure 3 also shows that senior researchers have an increased propensity to exit for most of the private sector consulting share distribution. However, the exit propensity effects are overall much smaller for private sector consulting compared to public sector consulting. Differentiating by field shows that in social science and engineering exit probability increases with consulting intensity, but decreases in the life sciences (Figure 2). In the social sciences exit is more likely with both increasing private and public sector consulting time-shares. In natural sciences there is a small increased propensity to exit for public sector consulting only, whereas in engineering it is mainly private sector consulting that drives exit (not presented).

Figure 3: Predictive margins for "exit" by rank (909 observations: age<65)




Note: Predictive margins are only shown for valid cases where consulting effects are significant.

Table A.5 shows the results of the probit estimation for exit in detail. Exit probability increases with age but assistant professors are least likely to stop publishing, followed by senior researchers. The better the ex-ante publication performance and international visibility, as measured by conference attendance, the less likely an academic is to stop publishing. The propensity of exit also decreases with other measures of research activity, such as public funding and peer group size within the institution. Exit is lower for those in the publication intensive fields of life and natural science compared to the less-publication intensive fields of humanities, social sciences and engineering. External knowledge transfer experience such as patenting and industry funding have no additional effect, however. We also do not find women to have a higher propensity to stop publishing.

Finally we estimate the effect of consulting on publication and citation output. The results from the endogenous switching models on research outcomes in the post-survey period are presented in Table 4 and Table 5. The model accounts for the selection into consulting and shows the outcome equation for consulting-active and non-consulting-active academics separately, thus allowing us to estimate the productivity equation for all academics and to compare the effect of control variables across the two sets of academics. Exiting academics, i.e. those that do not publish in the post-survey period, are excluded from these models but the results remain robust even when exiting academics are included. Results are shown for overall and for subject weighted publication and citation counts. The results show for consulting in general, as well as for both types of consulting, that (although the coefficients have negative signs) there are no significant effects on ex-post publication numbers (Table 4). However, we find that higher consulting shares are associated with fewer citations per paper (Table 5). Interestingly, when distinguishing public sector from private sector consulting we see that this effect is larger for public sector consulting. Academics lose on average one citation per publication published during the 2009-2013 period if they increase the time spent on public sector consulting by just three percentage points. An increase from 7% public consulting (the sample mean in the second stage) to 20% (the $90^{th}$ percentile) would then result in the loss of 3.5 citations per paper if everything else is held at the mean. This is a significant decline, considering that the average paper in our sample receives just 12 citations. The decline is slightly smaller for private sector consulting with the loss of 1.8 citations for the same increase in consulting time.

Moreover, we see in both tables that publication and citation performance is highly path-dependent. The pre-sample mean is positive, highly significant and the coefficients are similar in size for both consulting-active and non-consulting-active academics. We further find that publication output is larger for older academics and for professors. We do not find differences between men and women regarding their publishing once we use field-weighted publication counts. Scientific attributes such as public funding, collaborative reach and international visibility are all positively associated with publication output. We also find that publication numbers are lower for university academics, who have teaching obligations unlike most academics at PROs. Patents are positively associated with publication numbers for consulting-active academics only.

Looking instead at the average number of citations per publication control variable effects are less clear and seem to depend on the type of academic, i.e. whether they are consulting-active or not. For example, age and seniority effects are only found for consulting-active academics. For non-consulting-active academics we find that citations are negatively associated with industry funding, in line with some of the prior literature (e.g. Hottenrott and Thorwarth, 2011). Consulting-active academics, however, see no decline in citations associated with industry funding independent of the consulting time-share effect.

Table 4: Estimation results from endogenous switching models on number of publications (without "exits")

| Model | 1 | | 2 | 3 | | 4 |
|---|---|---|---|---|---|---|
| Dependent variable | ln(publications$_{2009-2013}$) | | ln(publications$_{2009-2013}$) | ln(weighted publications$_{2009-2013}$) | | ln(weighted publications$_{2009-2013}$) |
| Group | no consulting | consulting | consulting | no consulting | consulting | consulting |
| | coef. (s.e.) | coef. (s.e.) | coef. (s.e.) | coef. (s.e.) | coef. (s.e.) | coef. (s.e.) |
| **Consulting activities** | | | | | | |
| consulting share | | -.002 (.001) | | | <-.001 (.001) | |
| consulting share$^2$ | | <-.001 (<.001) | | | <-.001 (<.001) | |
| public consulting share | | | -.008 (.006) | | | -.004* (.002) |
| public consulting share$^2$ | | | <.001 (<.001) | | | <.001 (<.001) |
| private consulting share | | | .002 (.007) | | | <-.001 (.002) |
| private consulting share$^2$ | | | <-.001 (<.001) | | | <-.001 (<.001) |
| **Controls** | | | | | | |
| age | .100*** (.027) | .122*** (.040) | .124*** (.040) | .045*** (.015) | .075*** (.025) | .076*** (.025) |
| age$^2$ | -.001*** (<.001) | -.001*** (<.001) | -.001*** (<.001) | -.001*** (<.001) | -.001*** (<.001) | -.001*** (<.001) |
| female | .070 (.060) | -.144*** (.051) | -.139** (.057) | .041 (.028) | -.028 (.027) | -.026 (.027) |
| junior researcher | Reference category | | Reference category | Reference category | | Reference category |
| senior researcher | .230*** (.025) | -.057 (.053) | -.072 (.051) | .096*** (.009) | -.037* (.019) | -.043** (.020) |
| assistant professor | .302*** (.029) | .049*** (.015) | .034 (.023) | .148*** (.012) | -.002 (.018) | -.010 (.011) |
| full professor | .451*** (.022) | .122 (.084) | .111 (.084) | .218*** (.012) | .058*** (.007) | .052*** (.006) |
| ln(publications$_{2002-2008}$) | .509*** (.046) | .579*** (.013) | .581*** (.011) | | | |
| ln(weighted publications$_{2002-2008}$) | | | | .560*** (.029) | .650*** (.013) | .651*** (.012) |
| industry funding | -.410 (.273) | -.071 (.056) | -.105*** (.036) | -.121 (.109) | -.044 (.030) | -.050 (.039) |
| public funding | .131*** (.023) | .099*** (.023) | .115*** (.032) | .058*** (.008) | .024* (.010) | .029* (.017) |
| collaborative reach | .088*** (.019) | .035 (.024) | .038* (.020) | .037*** (.012) | .020* (.012) | .021** (.010) |
| international visibility | .223*** (.027) | .667*** (.093) | .666*** (.087) | .087*** (.026) | .319*** (.072) | .317*** (.071) |
| ln(peer group size) | .028 (.018) | .043*** (.016) | .042*** (.014) | .011 (.009) | .018** (.005) | .017*** (.004) |
| scientific field dummies | Included | | Included | Included | | Included |
| university | -.185*** (.032) | .046 (.060) | .041 (.066) | -.089*** (.016) | .016 (.013) | .015 (.015) |
| ln(patent$_{pre2009}$) | .094 (.061) | .122*** (.026) | .119*** (.027) | .040 (.027) | .084*** (.006) | .082*** (.007) |
| # observations | 822 | | 822 | 822 | | 822 |
| Log pseudolikelihood | -1290.05 | | -1289.61 | -696.43 | | -696.07 |
| rho (equ. 1/no consulting) | -.17 (0.11) | | -.17 (0.11) | -.19 (0.19) | | -.19 (0.19) |
| rho (equ. 1/consulting) | -.25** (0.11) | | -.22* (0.13) | -.29*** (0.09) | | -.27*** (0.08) |

*** (**,*) indicate a significance level of 1% (5%, 10%). All models contain a constant. Second stage results presented; for the specification of the first stage, see Table 3 model 1. Exclusion restrictions: 1-4 significant at 1%. level in the first stage.

Table 5: Estimation results from endogenous switching models on average citations per publication (without “exits”)

| Model | 1 | | 2 | 3 | | 4 |
|---|---|---|---|---|---|---|
| Dependent variable | ln(av. citations$_{2009-2013}$) | | ln(av. citations$_{2009-2013}$) | ln(weighted av. citations$_{2009-2013}$) | | ln(weighted av. citations$_{2009-2013}$) |
| Group | no consulting | consulting | consulting | no consulting | consulting | consulting |
| | coef. (s.e.) | coef. (s.e.) | coef. (s.e.) | coef. (s.e.) | coef. (s.e.) | coef. (s.e.) |
| **Consulting activities** | | | | | | |
| consulting share | | -.019** (.008) | | | -.012*** (.003) | |
| consulting share$^2$ | | <.001 (<.001) | | | <.001 (<.001) | |
| public consulting share | | | -.025*** (.013) | | | -.014*** (.004) |
| public consulting share$^2$ | | | <.001*** (<.001) | | | <.001*** (<.001) |
| private consulting share | | | -.011 (.008) | | | -.008* (.004) |
| private consulting share$^2$ | | | <-.001 (<.001) | | | <-.001 (<.001) |
| **Controls** | | | | | | |
| age | .025 (.105) | .054* (.030) | .058** (.028) | -.005 (.055) | .032*** (.010) | .034*** (.009) |
| age$^2$ | <.000 (.001) | -.001* (<.001) | -.001** (<.001) | <.000 (<.001) | <.000*** (<.001) | <.000*** (<.001) |
| female | -.031 (.097) | -.084 (.124) | -.077 (.132) | -.026 (.028) | <.001 (.050) | .003 (.055) |
| junior researcher | Reference category | | Reference category | Reference category | | Reference category |
| senior researcher | -.093 (.076) | .116*** (.007) | .099*** (.014) | -.036 (.025) | .087*** (.007) | .080*** (.011) |
| assistant professor | -.268*** (.061) | .229*** (.067) | .210** (.054) | -.126*** (.026) | .085*** (.031) | .078** (.030) |
| full professor | -.107 (.158) | .093 (.136) | .085 (.130) | -.057 (.046) | .049 (.083) | .044 (.086) |
| ln(av. citations$_{2002-2008}$) | .311*** (.070) | .337*** (.033) | .335*** (.033) | | | |
| ln(weighted av. citations$_{2002-2008}$) | | | | .473*** (.065) | .429*** (.054) | .426*** (.055) |
| industry funding | -.305** (.137) | .267 (.245) | -.213 (.200) | -.166*** (.026) | .137 (.107) | .114 (.076) |
| public funding | .151 (.135) | .046 (.049) | .070** (.033) | .081 (.067) | .028 (.023) | .038* (.020) |
| collaborative reach | .078*** (.021) | .021 (.016) | .025* (.015) | .022* (.012) | -.001 (.011) | .001 (.001) |
| international visibility | -.189 (.186) | .934*** (.150) | .942*** (.142) | -.086 (.099) | .439*** (.065) | .443*** (.062) |
| ln(peer group size) | .027 (.037) | .028 (.022) | 026 (.023) | .011 (.009) | .017 (.010) | .015 (.010) |
| scientific field dummies | Included | | Included | Included | | Included |
| university | -.143 (.127) | -.162 (.150) | -.168 (.143) | -.040 (.043) | -.080 (.077) | -.080 (.075) |
| ln(patent$_{pre2009}$) | -.003 (.045) | -.018 (.062) | -.020 (.062) | .018 (.034) | .008 (.024) | -.009 (.026) |
| # observations | 822 | | 822 | 822 | | 822 |
| Log pseudolikelihood | -1405.46 | | -1404.53 | -696.43 | | -829.77 |
| rho (equ. 1/no consulting) | .23 (0.32) | | .24 (0.31) | .06 (0.16) | | .06 (0.15) |
| rho (equ. 1/consulting) | -.16 (0.27) | | -.11 (0.25) | -.24 (0.18) | | -.22 (0.17) |

*** (**,*) indicate a significance level of 1% (5%, 10%). All models contain a constant. Second stage results presented; for the specification of the first stage, see Table 3 model 1. Exclusion restrictions: 1-4 significant at 1% level in the first stage.

## 5. Conclusions and implications

Our study contributes to the literature on academic consulting and its consequences. Investigating the effect of public and private sector consulting activities on exit from academia and publication performance in a sample of academics at universities and public research organisations in Germany, we demonstrate the importance of accounting for the selection into consulting. We find that, especially in the case of private sector consulting, a higher share of time devoted to consulting increases the probability of exit from academic work. This effect is strong for lower rank researchers, but also significant for faculty in permanent positions. Results from endogenous switching models further show that while generally less productive academics engage in consulting, it does not further reduce their ex-post research performance in terms of publication numbers. Our results thus generally do not confirm concerns related to a potential detrimental effect of consulting on future research disclosure. However, for public consulting, we see lower average citations per paper in the ex-post period. This finding suggests that while consulting with the private sector may be research driven or help inform research projects resulting in high quality publications, public sector consulting involves extensive report writing that attracts few citations. Yet, for academics in earlier stages of their academic career and also for senior academic staff, consulting activities may pave the way for alternative career paths or activities outside academic research, as indicated by exit from academic publishing.

The paper further showed that public and private consulting differ not only in their effects on ex-post performance but also in that they are undertaken by different types of academics. Age and seniority effects are stronger for public sector consulting, suggesting that private sector consulting is less driven by reputation and experience. We confirm prior research, finding that women are less likely than men to engage in private sector consulting, but that there are no gender differences with regard to public sector consulting. Private sector consulting is more common among engineering academics, while public sector consulting is more common in the humanities and social sciences. Private sector consulting is also associated with other channels of university-industry technology transfer such as contract research for industry and co-authoring with private sector employees, while for public sector consulting we observe that academics with a wider collaborative network and multiple institutional affiliations are more likely to be engaged. The latter observation points to reputation effects, which are not directly related to ex-ante performance in terms of scientific publications.

These differences between academics that provide consulting to the private vs. public sector have largely been ignored in the literature. Our findings suggest that these differences are important as they may help explain differences in research performance.

These findings have at least three important implications for research institutions and policy. First, the training and support for junior academics to engage in consulting with external actors can open up career options outside academic research. The provision of alternative options is important as not all those trained in academia are able to stay there (e.g. Stephan, 2012; Hottenrott and Lawson, 2015). However, support of external consulting could also lead to a brain drain at both junior and senior levels as academics cease to be engaged in scientific research. Consequently, more attention must be given to providing the right incentives for academics to continue academic as well as consulting activities. Second, policies to engage all academics with the external sector may be detrimental to academic research. Academics that do not engage in consulting are often less focussed on external interactions in general and engage in research that attracts more citations. One could conclude that these academics are more focussed on basic research less likely to be of immediate interest to external actors or sponsors. The effect may also reflect differences in research motivation, and to engage these academics in consulting may not be viable as they lack the necessary motivation to do so. Such individuals may as a result of such policies have their time diverted from research efforts resulting in a stronger detrimental effect of consulting than for more applied researchers. Third, academics that engage in consulting are on average involved in more grant based research and are highly connected. They may therefore serve as important brokers with external organisations, leveraging additional income for their institution while providing advice to external sectors. While this may come at the cost of lower quality research output, it may contribute to a division of labour within the academic institution that allows for different consulting and research patterns amongst academics.

We encourage further research on academic consulting especially regarding its role for inter-sector mobility of academics and for the evolution of career paths. Moreover, while we considered time-shares rather than monetary rewards for consulting, it would be desirable to better understand the link between remuneration and the effects of consulting on other academic activities. While well paid consulting that is informed by research may increase the academics' institutional research budget through follow-up research contracts and therefore facilitate growth and productivity of the research group, consulting activities that result in private income may be more prone to lead to a brain drain from academic work. It seems therefore crucial to further study the contractual mechanisms in future work.

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# Appendix

Table A.1: Correlation matrix of covariates (n = 951)

| | 1 | 2 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 13 | 14 | 15 | 16 | 17 | 18 | 19 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 age | 1.00 | | | | | | | | | | | | | | | | |
| 2 female | -.12*** | 1.00 | | | | | | | | | | | | | | | |
| 4 rank | .21*** | -.07* | 1.00 | | | | | | | | | | | | | | |
| 5 publications$_{2002\text{-}2008}$ | .09** | -.08** | .17*** | 1.00 | | | | | | | | | | | | | |
| 6 citations$_{2002\text{-}2008}$ | .01 | -.06 | .15*** | .83*** | 1.00 | | | | | | | | | | | | |
| 7 average citations$_{2002\text{-}2008}$ | -.10** | -.06 | .03 | .27*** | .51*** | 1.00 | | | | | | | | | | | |
| 8 collaborative reach | -.13*** | -.09** | .05 | .24*** | .25*** | .26*** | 1.00 | | | | | | | | | | |
| 9 international visibility | -.04 | -.03 | .01 | .09** | .08* | .12*** | .14*** | 1.00 | | | | | | | | | |
| 10 industry funding | .07* | -.07* | .04 | .02 | -.01 | -.06 | .09** | -.05 | 1.00 | | | | | | | | |
| 11 public funding | .08* | -.05 | .03 | .13*** | .10** | .05 | .08* | -.04 | .17*** | 1.00 | | | | | | | |
| 12 group leader | .07* | -.06* | .46*** | .15*** | .13*** | .08* | .23*** | .07* | .12*** | .15*** | 1.00 | | | | | | |
| 13 peer group size | .01 | -.06 | -.03 | .04 | .11*** | .13*** | .07* | -.03 | .12*** | .17*** | .03 | 1.00 | | | | | |
| 14 university | .10** | .01 | .62*** | .04 | -.00 | -.07* | -.06 | -.02 | -.09** | -.01 | .28*** | -.08* | 1.00 | | | | |
| 15 multiple affiliation | -.08* | .01 | -.07* | .01 | .02 | .03 | .07* | .01 | .05 | .04 | -.03 | -.02 | .01 | 1.00 | | | |
| 16 patents$_{pre2009}$ | .06 | -.06 | -.02 | .08* | .06 | -.01 | .06 | -.01 | .10** | .20*** | .05 | .01 | -.08* | -.01 | 1.00 | | |
| 17 firm | .12*** | -.08* | .13*** | .09** | .06* | -.03 | .05 | -.00 | .20*** | .18*** | .11*** | .05 | .08** | .06 | .15*** | 1.00 | |
| 18 techtransfer industry | .03 | - | .04 | .07* | .04 | -.04 | .12*** | -.01 | .18*** | .19*** | .16*** | .09** | -.04 | .07* | .21*** | .31*** | 1.00 |
| 19 coauthorship industry | .03 | -.10** | .05 | .09** | .01 | -.05 | .08* | .06 | .12*** | .17*** | .12*** | .01 | .04 | .10** | .19*** | .22*** | .37*** |

Notes: Rank is the ordinal version of the rank dummies (rank=1: Junior Researcher, rank=2: Senior Researcher, rank=3: Assistant Professor, rank=4: Full Professor). * $p<0.05$, ** $p<0.01$, *** $p<0.001$.

Table A.2: Academics' division of time (in % of total time at work)

| | obs. | Research mean (s.d.) | Grant-funded research mean (s.d.) | Teaching mean (s.d.) | Admin. mean (s.d.) | Public sector consulting mean (s.d.) | Private sector consulting mean (s.d.) |
|---|---|---|---|---|---|---|---|
| **Full sample** | **951** | **32.14 (22.7)** | **19.96 (20.85)** | **21.47 (16.64)** | **21.12 (16.38)** | **3.06 (7.96)** | **2.25 (6.23)** |
| **By Rank** | | | | | | | |
| Junior Researcher | 90 | 31.64 (31.07) | 35.47 (32.70) | 8.94 (15.59) | 16.93 (21.42) | 5.61 (16.21) | 1.40 (3.51) |
| Senior researcher | 243 | 40.67 (24.59) | 22.53 (22.30) | 9.50 (10.52) | 21.07 (19.22) | 3.02 (7.39) | 3.20 (8.80) |
| Assistant professor | 107 | 37.79 (26.34) | 22.09 (22.46) | 21.48 (14.73) | 15.05 (14.13) | 2.08 (6.58) | 1.50 (6.97) |
| Full professor | 511 | 26.98 (17.09) | 15.57 (14.73) | 29.36 (14.74) | 23.16 (13.70) | 2.83 (6.00) | 2.10 (4.75) |
| **By Discipline** | | | | | | | |
| Social Sciences | 199 | 24.84 (23.79) | 22.25 (20.1) | 28.11 (18.55) | 19.24 (15.13) | 3.92 (7.7) | 1.63 (5.09) |
| Life Sciences | 284 | 34.69 (22.21) | 19.32 (21.87) | 18.52 (14.18) | 21.98 (16.28) | 3.47 (7.87) | 2.02 (7.05) |
| Natural Sciences | 292 | 32.01 (22.14) | 22.39 (23.36) | 21 (16.68) | 21.45 (17.89) | 1.92 (5.82) | 1.23 (3.31) |
| Engineering | 176 | 36.49 (21.31) | 14.39 (13.24) | 19.48 (16.03) | 21.33 (15.19) | 3.32 (10.82) | 5.00 (8.54) |
| **By Consulting** | | | | | | | |
| Consulting *in*active | 537 | 33.82 (24.93) | 22.50 (23.24) | 22.66 (17.73) | 21.02 (17.68) | 0 | 0 |
| Consulting active | 414 | 29.96 (19.24) | 16.67 (16.74) | 19.92 (14.99) | 21.26 (14.53) | 7.03 (10.86) | 5.17 (8.61) |
| Pr(\|T\| > \|t\|) | | *** | *** | ** | | *** | *** |

*** (**,*) indicate a significance level of 1% (5%, 10%). Variable means presented. Standard deviations in parentheses.

Table A.3: Academics' engagement in consulting (in % of individuals)

| | obs. | Consulting mean (s.d.) | Public sector consulting mean (s.d.) | Private sector consulting mean (s.d.) |
|---|---|---|---|---|
| **Full sample** | **951** | **.44 (.50)** | **.31 (.46)** | **.27 (.44)** |
| **By Rank** | | | | |
| Junior Researcher | 90 | .38 (.49) | .29 (.46) | .18 (.38) |
| Senior researcher | 243 | .42 (.50) | .26 (.44) | .28 (.45) |
| Assistant professor | 107 | .23 (.43) | .16 (.37) | .11 (.32) |
| Full professor | 511 | .49 (.50) | .37 (.48) | .31 (.46) |
| **By Discipline** | | | | |
| Social Sciences | 199 | .48 (.50) | .39 (.49) | .18 (.39) |
| Life Sciences | 284 | .46 (.50) | .34 (.48) | .27 (.45) |
| Natural Sciences | 292 | .30 (.46) | .22 (.41) | .18 (.39) |
| Engineering | 176 | .57 (.50) | .31 (.46) | .49 (.50) |

Table A.4: Academics' "exit" rates (in % of individuals)

| | Exit | |
|---|---|---|
| | obs. | mean (s.d.) |
| **Full sample** | **951** | **.14 (.34)** |
| **By Rank** | | |
| Junior Researcher | 90 | .19 (.39) |
| Senior researcher | 243 | .13 (.33) |
| Assistant professor | 107 | .10 (.31) |
| Full professor | 511 | .14 (.34) |
| **By Discipline** | | |
| Social Sciences | 199 | .29 (.46) |
| Life Sciences | 284 | .05 (.21) |
| Natural Sciences | 292 | .08 (.28) |
| Engineering | 176 | .19 (.40) |

Table A.5: Estimation results from probit models (with selection) on "exit"

| Model | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| | coef. (s.e.) | coef. (s.e.) | coef. (s.e.) | coef. (s.e.) |
| **Consulting activities** | | | | |
| consulting share | .029*** (.006) | | .032*** (.006) | |
| consulting share² | -.0002 (.0001) | | >.000 (.000) | |
| public consulting share | | .011** (.006) | | .020*** (.007) |
| public consulting share² | | .0002* (.0002) | | >.001 (.000) |
| private consulting share | | .026*** (.008) | | .023*** (.006) |
| private consulting share² | | -.0003 (.0002) | | >.000 (.000) |
| **Controls** | | | | |
| age | .022*** (.005) | .023*** (.005) | .029*** (.010) | .030*** (.011) |
| female | .008 (.159) | .001 (.181) | .029 (.154) | .020 (.166) |
| junior researcher | Reference | Reference | Reference | Reference |
| senior researcher | -.320*** (.029) | -.259*** (.033) | -.397*** (.050) | -.343*** (.048) |
| assistant professor | -.579*** (.048) | -.509*** (.028) | -.684*** (.068) | -.595*** (.035) |
| full professor | -.283* (.169) | -.273* (.151) | -.348 (.261) | -.329 (.237) |
| field-weighted publications$_{2002-2008}$ | -.616*** (.108) | -.627*** (.103) | - .642 *** (.105) | -.654*** (.100) |
| field-weighted average citations$_{2002-2008}$ | -.120 (.123) | -.129 (.117) | -.111 (.129) | -.119 (.127) |
| industry funding | .292 (.411) | .311 (.389) | .483 (.395) | .574 (.374) |
| public funding | .287 (.208) | .282 (.214) | .379** (.158) | .368** (.155) |
| collaboration reach | -.045 (.018) | -.033 (.016) | -.031 (.032) | -.022 (.031) |
| international visibility | -1.142*** (.267) | -1.337*** (.339) | -1.021*** (.326) | -1.039*** (.361) |
| ln(peergroup size) | -.118*** (.022) | -.126*** (.026) | -.156*** (.030) | -.137*** (.025) |
| university | .061 (.207) | .068 (.203) | -.040 (.287) | -.042 (.275) |
| social sciences | Reference | Reference | Reference | Reference |
| life sciences | -.824*** (.097) | -.843*** (.095) | -1.007*** (.090) | -1.016*** (.084) |
| natural sciences | -.783*** (.078) | -.812*** (.067) | -.836*** (.061) | -.857*** (.066) |
| engineering | -.261 (.235) | -.273 (.198) | -.328 (.219) | -.307* (.201) |
| ln(patents$_{pre2009}$) | -.029 (.046) | -.043 (.046) | -.089 (.147) | -.095 (.145) |
| # observations | 951 (full sample) | 951 (full sample) | 909 (age < 65) | 909 (age < 65) |
| Log pseudolikelihood | -677.44 | -676.73 | -644.33 | -643.67 |
| rho (equ.1/2) | 1.24* (.65) | 1.05* (.55) | .90*** (.10) | .87*** (.12) |
| AIC | 1360.88 | 1359.45 | 1294.66 | 1293.33 |

Notes: *** (**,*) indicate a significance level of 1% (5%, 10%). Both models contain a constant. Clustered standard errors in parenthesis. Second stage results presented; for the specification of the first stage, see Table 3 model 1. Exclusion restrictions: 1-4 significant at 1%.