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## **Public and Private Sector Consulting and Academic Research**

### **Performance**

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### **Abstract**

We study public and private sector consulting activities of academic scientists. Such activities attract attention in the context of knowledge and technology transfer (KTT) and university-industry interactions (UII). In a sample of 983 German researchers, we distinguish between researchers' personal, institutional, scientific and commercial attributes that help to explain much of the variation in consulting activities. We find that private sector consulting co-occurs with other channels of knowledge and technology transfer like patenting and co-authoring with industry researchers. While previous research suggested that consulting activities might come at the cost of reduced research performance, our analysis does not confirm this concern. We conclude that while in some disciplines ex-ante research performance and consulting are indeed negatively correlated, research outcomes in terms of publication may not necessarily suffer. The results, however, suggest that higher engagement in consulting, especially for the private sector, increases the probability of exit from academe.

## 1. Introduction

In light of the considerable amounts governments spend on funding universities and public research organizations (PROs), there is a high political and scientific interest in the design and effectiveness of knowledge and technology transfer (KTT) mechanisms that increase economic payoffs from such public investments (OECD 2014).

The KTT mechanism of interest in this study is academic consulting (AC). AC is the most widespread activity compared to other KTT mechanisms like for example collaborative and contract research, patenting, and spinoff company formation (Perkmann et al., 2013, Klofsten and Jones-Evans, 2000). Academic consulting is usually defined as a form of professional consulting 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, generating reports, resolving problems as well as generating or testing new ideas (Perkmann and Walsh, 2008).

Although it is among the most popular engagement activities for scientists, AC 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). Only relatively recently academic consulting has been studied in different institutional environments (e.g. Link et al., 2007; Jensen et al., 2010; Perkmann, 2011; Rentocchini et al., 2013; Amara et al., 2013; D’Este et al., 2013).

However, we still know little about factors that influence AC and how it relates to researchers’ individual, institutional, commercial, and scientific attributes. In particular, AC may not only depend on a researcher’s scientific attributes, but also on the engagement in complementary activities like patenting, co-authoring and other forms of KTT engagement.

It is further not obvious what role scientific merit reflected in research productivity, tenure, prestigious grants, awards, or group leadership plays for consulting activities. While some studies find that consulting is positively associated with top-ranked researchers (Perkmann et al., 2011), others find lower-rated research departments (D’Este and Perkmann, 2011) or less research active individuals (Haucap and Thomas 2014) to be more consulting active. These diverging results may suggest differences across disciplines and types of consulting. Previous research, however, almost exclusively focused on consulting to the private sector although public sector consulting also constitutes a relevant channel of knowledge transfer (Amara et al., 2013, Haucap and Thomas 2014).

Likewise, it seems crucial to study the effects of consulting activities on the individual ex-post research performance in terms of scientific publications, delay and secrecy, research agenda, research collaboration and exit from academia. In the academic consulting literature, there is an ongoing debate dating back to the late 1960s, in which external engagement of publicly funded researchers is controversial. Sceptics argue that consulting or external engagement may distract scientists from their primary roles of teaching and research, it reduces the quality of research output and it alters research agendas towards more applied foci (Boyer and Lewis 1984, Buenstorf, 2009, Rentocchini et al., 2013). Proponents endorse AC for knowledge and technology transfer purposes, revenue opportunities for the academic and the university as well as incentives to retain good scientists at the university or public research institution (Buenstorf, 2009).

Following the above discussion, we derive the following leading research questions: Which researchers engage in consulting? Is there a difference between public and private sector consulting? How does consulting affect research outcomes in the long run?

Using survey and individual researchers' bibliometric data, we investigate the personal, institutional, scientific and commercial factors that explain public and private sector consulting activities. With regard to outcomes, we study the effects of engagement in different types of consulting on the probability that consulting researchers exit from academic research, and for those remaining in academe, how consulting affects ex-post scientific publications.

In the present study, we build on data from a survey of academic researchers in Germany. The survey targeted researchers employed at universities or public research institutions in the social sciences, engineering, life science and natural sciences. We complement the survey data with publication data from ISI web of knowledge as well as with patent data from the European Patent Office (EPO) and the German Patent and Trademark Office. We make use of researchers' time distributions in a usual workweek to identify the occurrence and intensity of consulting activities. Further, we derive measures for the researchers' scientific profiles, their international visibility as well as for commercial engagement and other entrepreneurial behaviours.

In our sample of 983 researchers, 44% engage in some form of consulting (17% public, 13% private, and 14% both) and researchers spend, on average, 5.5% of their time in consulting (12.4% among consulting-active ones). In general, we find that full professors exhibit higher degrees of consulting compared to senior researchers and assistant professors. Further, consulting-active researchers are typically older, engage also in other knowledge and technology transfer activities, are more often multiply affiliated, have a higher international visibility, and

possess a smaller ex-ante publication stock than non-consultants. Public sector consulting most frequently appears in the social and life sciences. It is positively correlated with being female, leading a research group, and more collaboration within academe. Private sector consultants on the other hand is most popular among engineers and is positively correlated with international visibility.

Taking the selection of researchers into consulting activities into account, our analysis of research outcomes does not find lower ex-post scientific publication numbers, although it finds an increased probability to exit academe (zero subsequent publications) and a negative effect on the average number of citations per publication for those staying research active.

This article proceeds as follows: The theoretical background on researchers consulting activities is presented in section 2. We describe the data and methodology in section 3 and present the results in section 4. Section 5 concludes and discusses implications.

## 2. Researchers as consultants

Academic consulting is a widely practiced form of professional consulting performed by researchers who apply their professional or scholarly expertise outside their academic institution usually for some form of compensation. It involves providing advice, generating reports, resolving problems as well as generating or testing new ideas (c.f. Perkmann and Walsh, 2008). Consulting activities, however, vary in several dimensions. For example, academic consulting may differ considerably in its remuneration (fee-based or access to materials/data), contractor (private or public), scope (time and resources), formalisation (formal or informal), motivational drivers (opportunity-driven, commercialization-driven and research-driven, Perkmann and Walsh, 2007) and outcomes (publication, patent, technical or strategic solution).

Academic consulting is not a new phenomenon since universities are traditionally committed to provide their expertise to external institutions since their early days of founding (Shimshoni, 1970; Krinsky, 2003; Stephan, 2012). The popularity of AC among researchers stems mainly from its versatile, cost-effective, rapid, and selective means of knowledge transfer from university to industry without extensive involvement of university personnel and material resources (Klofsten and Jones-Evans, 2000).

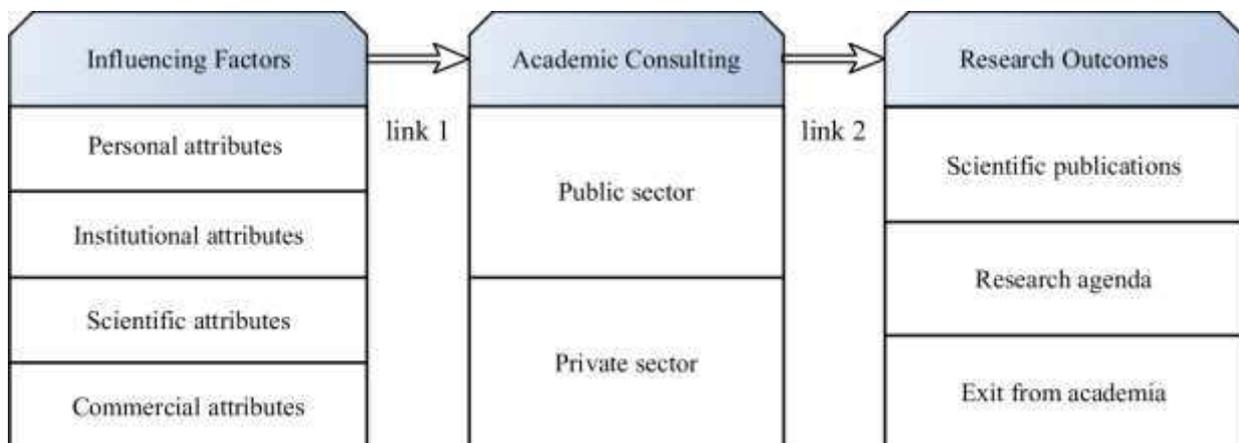
In the literature, AC is prominently discussed in broader contexts of informal technology transfer (e.g. Klofsten and Jones-Evans, 2000, Link et al. 2007, Grimpe and Hussinger, 2013), university-industry interactions (e.g. Perkmann and Walsh 2009), knowledge spillover theory (e.g. Jensen

et al. 2010), or university research funding through the private sector (Hottenrott and Thorwarth 2011, Lawson 2013, Hottenrott and Lawson 2014, Czarnitzki et al. 2014).

Compared to other channels of industry engagement by academic scientists, AC is more widespread among academics than patenting and academic entrepreneurship (D’Este and Patel, 2007, Klofsten and Jones-Evans, 2000). For example, Perkmann et al. (2013) compare researchers’ involvement in activities like collaborative research, consulting, sponsored research, contract research, patenting and academic entrepreneurship. Their results indicate that scientists’ involvement in private sector consulting varies significantly between countries, ranging from 17% in Germany up to 68% in Ireland, while scientists were less frequently involved in other forms of external engagement.

The AC literature can be broadly categorized into two streams of research (Figure 1). The first stream (link 1) identifies personal, institutional, scientific and commercial characteristics as important influencing factors for AC activities. The second stream (link 2) studies the effects of AC activities on research outcomes, i.e. scientific publications, delay and secrecy, research agendas, collaborative behaviour or exit from academia. Figure 1 illustrates these two research streams and serves as a framework in our following analysis.

Figure 1: Analytical framework of academic consulting



Regarding link 1, we identify 12 empirical studies (section 3.2.) from various countries and academic fields that focus on predictors of AC (see Table A1). While five of those articles focus on consulting in general and six articles focus on private sector consulting, only one study investigates differences between public and private sector consulting. The division of the contractor (or recipient) of consulting is important because it helps to get a better understanding the consulting phenomenon. Personal, institutional, scientific and commercial attributes may

affect public and private sectors differently. Similarly, one may expect different types of consulting to affect academic research performance differently.

We identify three studies regarding link 2 (section 3.3.) that explicitly explore the influence of consulting on research performance (see Table A2). Additionally, there is a slightly larger set of research on the relationship between research funding (grants/sponsorship) and research outcomes. Research funding, especially from the private sector may comprise consulting income besides contract research and other forms of compensation. The objective of the following analysis is thus to study the impact of AC on research outcomes taking into account those researcher and institutional characteristics that drive AC.

### 3. Empirical analysis

#### 3.1. Data and descriptive statistics

The following analysis builds on data from an online survey of academic researchers in Germany. The survey was conducted by the Centre for European Economic Research (ZEW) in 2008 and targeted researchers at universities or public research institutions in social sciences, engineering, life science and natural sciences. The survey yielded a sample population of about 16 thousand scientists of which 2,797 researchers answered the survey. We complement the survey data with publication data from ISI web of knowledge. In particular, we performed text field searches on the researchers' names in the publication database (articles, books, reviews, proceedings) and manually screened matches based on CV information. Further, we searched the Espace database of the European Patent Office and the database of German Patent Office for patents on which the researchers appear as inventor. As in the case of publications, all matches had been manually checked which yields a publication and patent record for all individual scientists from their first data base entry until 2013. Removing observations with incomplete records, the final sample comprises 983 researcher-level observations.

#### **Consulting activities**

The main variables of interest is the time-share that researchers devote to specific activities. These include research, teaching, administrative duties, and consulting (consulting share). With regard to consulting, we differentiate between private sector consulting (private consulting share) and consulting to the public sector (public consulting share). In a typical week researchers spend about 50% of their time on research, about 22% on teaching and roughly 5.5% on consulting (among consulting-actives the average time share is 12.4%). The relative importance of consulting varies across academic ranks and disciplines (Table A1). When distinguishing between private sector and public sector consulting, we observe interesting differences between

disciplines. In the social sciences, public sector consulting is more prevalent than private sector consulting, while in life sciences and natural sciences the difference is less pronounced. In engineering, we see the highest consulting share in total time with a slightly larger time-share devoted to industry consulting. From these time-shares, we identify consulting-active academics. Thus, we generate an indicator variable (*consulting*) that is equal to one, if the researcher devotes some positive amount of time to consulting, either to industry or public institutions. If a researcher has a positive time-share for private (public) sector consulting, another indicator variable (*private consulting*; *public consulting*) is set equal to one. We see from Table 1 that while the overall time devoted to AC is not high, 44% of the academics do at least some consulting. About 27% of researchers consult private sector companies, 31% public institutions and 14% engage in both types of consulting.

## 3.2. Factors influencing academic consulting ([link 1](#))

### **Personal attributes**

Previous studies stressed the relevance of personal attributes in explaining AC. Link et al. (2007) and Grimpe and Fier (2010) find that male researchers are more likely to engage in paid industry consulting. Louis et al. (1989) and Rentocchini et al. (2013) observe a positive correlation with a researcher's age and experience. Similarly, several studies find tenured faculty to be more likely to engage in AC (Link et al. 2007, Boardman and Ponomariov 2009). Previous results, however, also suggest that different personal attributes may be associated with different types of consulting. D'Este and Perkmann (2011), for example, find collaborative forms of interaction to be strongly driven by research-related motives and that younger researchers are more likely to consult private sector companies. On the other hand, Amara et al. (2013) observe emeriti to be more consulting active, but only in case of unpaid public consulting. In our sample researchers are, on average, 49 years old (age), 54% have tenured positions (tenure) and 15% of them are female. About 10% of the researchers in the sample do not yet hold doctoral degree (researcher), 26% are senior researchers or principle investigators (senior researcher), 11% are post docs or assistant professors (assistant professor) and 54% are associate or full professors (full professor).

### **Scientific attributes**

Several studies stress the importance of scientific merit for explaining consulting activities. Perkmann et al. (2011) for example find that consulting is positively associated with top-ranked researchers. To the contrary, D'Este and Perkmann (2011) find lower-rated research departments to be more consulting active and Haeussler and Colyvas (2011) find that researchers who assess

publication performance to be important for their reputation among peers, were less consulting active.

Moreover, one could expect researchers that are more visible through larger collaborator networks or participation in international conferences to be more consulting active. However, larger scientific visibility and networking may also be related to less consulting, if it reflects the researcher's taste for traditional research dissemination channels as compared to knowledge transfer activities. Given these multiple dimensions of scientific attributes, we consider publication activities as well as the collaborative reach and the international visibility as possible influencing factors. In our sample, researchers published on average 24 items during their career (up to 2013). The median value is, however, much lower with about 9 publications (publications). Like the publication distribution, the citations distribution is highly skewed. The average number of overall citations is 498, while half of the sample has less than 50 citations in total (citations). Looking at the average number of citations per publication (average citations), we find a similar, but less skewed distribution (15 vs. 7). To measure the individual's research collaboration outreach, we construct a measure based on the location of co-authors of each researchers (collaborative reach) similar to the concept of "collaboration cosmopolitanism" by Bozeman and Corley (2004). The variable takes values from zero to five, while 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 4 and 5 capture collaboration with North America and the rest of the world, respectively. International visibility on the other hand, is measured based on international conference participation (international visibility). The variable reflects the share of international conferences in all conferences attended.

As an alternative measure of research performance, several studies suggest a relationship between grant-based research funding and consulting. For example Link et al. (2007) find that scientists who devote a higher percentage of their time to grants related research are more likely to engage in informal technology transfer including consulting. Their explanation for this connection lies within the third party confirmation of research excellence. By separating competitive and contract funding, D'Este et al. (2013) directly address the relationship between funding and consulting. They find the amount of contract funding for research to have a positive impact on the extent of consulting activities while national level competitive funding has no significant effect and international level competitive funding has a negative effect. Amara et al. (2013) find a negative effect of internal funding and a positive effect of industry funding on paid consulting. Likewise, Boardman and Ponomariov (2009) suggest that industry grants increase the likelihood of university scientists to initiate contracts to private companies for consulting

purposes. Finally, also Landry et al. (2010) provide evidence that private-sector funding has a positive and significant impact on knowledge transfer activities including consulting.

Thus, we consider researcher's grant-based research income from the EU (eu funding), national government (gov. funding), science foundations (scientific funding), and industry (industry funding) in millions of euros. The mean values obtained in the data for external funding vary between .16 million Euro from industry funding to .45 million Euro from EU funding (.36 from Government, .31 from scientific foundations). For further details, see Table 1.

### **Institutional attributes**

Several studies suggest that the scientific discipline and institutional environment plays a role in consulting activities (e.g. Louis et al., 1989; Link et al., 2007; Amara et al., 2013; D'Este et al., 2013). For example, Landry et al. (2010) show that consulting intensity increases if the field is engineering rather than life sciences. Therefore, we distinguish broadly between four scientific disciplines. Of the researchers in the sample, 21% belong to social sciences, 30% to life sciences, 31% to the natural sciences and 19% are active in engineering. Besides the field, other institutional factors shape an individual's research environment. Research organization works differently at institutions that provide education compared to non-university research centres where researchers have no teaching obligations. More than half (59%) of the researchers in the sample are employed at universities (university), while the remainder work at public research organisations or other institutions (including companies). Further, 1.5% of the researchers have multiple affiliations, i.e. report to be affiliated with a university and a public research organisation or a university and another institution.

Being in the position of a research group leader may affect both, the opportunity for consulting as well as the capacity to do so (Grimpe and Fier, 2010). In our data, about 71% of the researchers do head a research group (group leader). Likewise, the size of the local peer group, i.e. the number of people within the same institution working in closely related fields (peergroup size) may affect a researcher's outward orientation and the possibility to delegate or reallocate certain tasks (Landry et al. 2010). Peer group size is 10 people at the median and about 40 at the mean.

### **Commercial attributes**

Louis et al. (1989) were among the first to point out that other entrepreneurial behaviours (OEB), may contribute to predict any particular form of entrepreneurship (like consulting). Also Haeussler and Colyvas (2011) and Landry et al. (2010) find that consulting correlates with spin-off creation and other informal knowledge transfer activities. Likewise patent applications and patent citations (Jensen et al. 2010) have been shown to have a positive and significant effect on

consulting (e.g. Grimpe and Fier, 2010; Amara et al., 2013). Boardman and Ponomariov (2009) stress the role of personal attitudes towards commercialization. Researchers sceptical towards commercialization in terms of industrial applications may still favour consulting for public sector institutions. Thus, we construct indicators for the commercial activities of the researchers. Besides 14% patent inventorship (`patents_d`), we count the number of patents (`patents`) which is about 1.3, on average, but much higher among patent-active researchers (about eight). About 17% of the researchers had been involved in starting a new firm (`firm_d`), 43% are engaged in technology transfer activities with the private sector (`techtransfer industry`), 22% have co-authors in the private sector (`coauthorship industry`) and 16% do paid consulting to the private sector (`paid consulting industry`).

Table 2 presents the personal, scientific, institutional and commercial attributes by consulting activity. We observe interesting differences in these variables between consulting-active and other researchers. Consulting-active researchers are, on average, slightly older, have more often tenure, i.e. are full professors. Assistant professors are much less often engaged in consulting, and female researchers are less likely to do industry consulting, but not less likely than men to engage in public consulting.

In terms of scientific publications or the number of citations to these publications, we find no significant difference in their numbers, but the average number of citations per publication is lower in the consulting-active group. The difference is most pronounced in the group of researchers who solely engage in private sector consulting. We do not observe differences in international visibility between the groups, but researchers who engage in both types of consulting have a higher collaborative reach than non-consultants.

Further, consultants have higher research grant income from science foundation and the private sector and more often head a research group. We do not find a difference between university researchers and researchers at public research organisations, but multiple affiliations are more common in the group of consultants to the public sector as well as in the group that do both types of consulting.

Finally, entrepreneurial experience, co-authorship with researchers in the private sector and patenting is much more frequent among private sector consultants, but not among public consultants.

Table 1: Descriptive statistics

Variable	unit	source	median	mean	s.d.	min.	max.
<b>Consulting activities</b>							
consulting	binary	Survey	0	.44	.50	0	1
private consulting	binary	Survey	0	.27	.45	0	1
public consulting	binary	Survey	0	.31	.46	0	1
consulting share	percentage	Survey	0	5.48	1.42	0	100
private consulting share	percentage	Survey	0	2.34	6.43	0	100
public consulting share	percentage	Survey	0	3.13	8.04	0	100
<b>Personal attributes</b>							
age	count	Survey	49	49.32	8.29	28	74
female	binary	Survey	0	.15	.36	0	1
tenure	binary	Survey	1	.54	.50	0	1
researcher	binary	Survey	0	.096	.294	0	1
senior researcher	binary	Survey	0	.257	.437	0	1
assistant professor	binary	Survey	0	.110	.313	0	1
full professor	binary	Survey	1	.537	.499	0	1
<b>Scientific attributes</b>							
publications	count	ISI WoS	9	23.54	37.68	0	306
citations	count	ISI WoS	49	497.99	1,227.43	0	17,139
average citations	fraction	ISI WoS	6.86	15.47	26.46	0	281.11
collaborative reach	ordinal	Survey	3	3.07	1.35	0	5
international visibility	fraction	Survey	.71	.69	.17	0	1
eu funding	amount	Survey	.05	.45	1.50	0	25
gov. funding	amount	Survey	0	.36	1.81	0	50
scientific funding	amount	Survey	.05	.31	.68	0	9.5
industry funding	amount	Survey	0	.16	.64	0	11
other funding	amount	Survey	0	.07	.36	0	6.9
<b>Institutional attributes</b>							
group leader	binary	Survey	1	.71	.45	0	1
peergroup size	count	Survey	10	39.54	146.85	0	3,000
social sciences	binary	Survey	0	.21	.41	0	1
life sciences	binary	Survey	0	.30	.46	0	1
natural sciences	binary	Survey	0	.31	.46	0	1
engineering	binary	Survey	0	.19	.39	0	1
university	binary	Survey	1	.587	.493	0	1
multiple affiliation	binary	Survey	0	.105	.306	0	1
<b>Commercial attributes</b>							
patents	count	EPO/DPMA	0	1.33	4.79	0	50
patents_d	binary	EPO/DPMA	0	.14	.34	0	1
firm_d	binary	Survey	0	.17	.38	0	1
techtransfer industry	binary	Survey	0	.43	.50	0	1
coauthorship industry	binary	Survey	0	.22	.41	0	1
paid consulting industry	binary	Survey	0	.16	.37	0	1

Notes: Number of observations: 983.

Table 2: Descriptive statistics by type of consulting

	Only private sector consulting	Only public sector consulting	Private and public sector consulting				No consulting
	I.	II.	III.	I vs. IV	II vs IV	III vs IV	IV.
Observations	129	168	138				548
Variables	mean (sd)	mean (sd)	mean (sd)	t-test	t-test	t-test	mean (sd)
<b>Personal attributes</b>							
age	49.11 (8.69)	49.93 (8.24)	51.86 (8.02)		*	***	48.54 (8.15)
female	.07 (.26)	.21 (.41)	.094 (.293)	***		**	.16 (.37)
tenure	.52 (.50)	.58 (.49)	.70 (.46)		**	***	.49 (.50)
researcher	.08 (.27)	.11 (.31)	.06 (.24)			*	.11 (.31)
senior researcher	.34 (.48)	.23 (.42)	.21 (.41)	*			.26 (.44)
assistant professor	.06 (.24)	.08 (.28)	.03 (.17)	***	**	***	.15 (.36)
full professor	.52 (.50)	.58 (.49)	.70 (.46)		**	***	.49 (.50)
<b>Scientific attributes</b>							
publications	22.33 (45.51)	19.64 (32.15)	27.62 (43.70)				23.99 (35.51)
citations	397.07 (1,116.25)	419.14 (1,455.5)	524.15 (1,226.69)				539.34 (1,176.11)
average citations	9.74 (14.12)	11.40 (19.90)	13.72 (26.01)	***	***	*	18.51 (29.96)
collaborative reach	2.95 (1.30)	3.12 (1.32)	3.42 (1.29)			***	3.00 (1.38)
international visibility	.69 (.16)	.68 (.14)	.71 (.12)				.69 (.19)
eu funding	.35 (.65)	.38 (.92)	.75 (1.75)			**	.43 (1.69)
gov. funding	.41 (1.10)	.35 (.72)	.49 (1.40)				.33 (2.22)
scientific funding	.29 (.70)	.37 (.94)	.52 (.84)		**	***	.25 (.50)
industry funding	.46 (1.16)	.07 (.23)	.31 (.99)	***		***	.08 (.35)
other funding	.03 (.12)	.11 (.40)	.16 (.69)		***	***	.04 (.23)
<b>Institutional attributes</b>							
group leader	.73 (.45)	.74 (.44)	.83 (.37)		*	***	.67 (.47)
peergroup size	40.29 (103.57)	31.48 (74.47)	62.39 (298.72)			*	36.09 (109.54)
social sciences	.15 (.36)	.39 (.49)	.13 (.34)		***	*	.19 (.50)
life sciences	.27 (.45)	.32 (.47)	.33 (.47)				.28 (.45)
natural sciences	.18 (.38)	.20 (.40)	.25 (.43)	***	***	***	.38 (.49)
engineering	.40 (.49)	.08 (.28)	.29 (.46)	***	*	***	.14 (.35)
university	.52 (.50)	.60 (.49)	.62 (.49)				.59 (.49)
multiple affiliation	.09 (.29)	.16 (.37)	.15 (.36)		***	***	.08 (.27)
<b>Commercial attributes</b>							
patents	3.58 (7.89)	.39 (1.68)	1.94 (5.80)	***	*	*	.94 (3.94)
patents_d	.27 (.45)	.07 (.25)	.20 (.40)	***	*	***	.11 (.31)
firm_d	.27 (.45)	.13 (.33)	.37 (.48)	***		***	.11 (.32)
techtransfer industry	.84 (.37)	.30 (.46)	.75 (.43)	***		***	.29 (.46)
coauthorship industry	.43 (.50)	.16 (.37)	.39 (.50)	***		***	.14 (.35)
paid consulting industry	.45 (.50)	.05 (.21)	.41 (.49)	***		***	.07 (.25)

Notes: Reading example: 7% of only private sector consultants are female while 21% of public sector consultants are female and 16% of non-consultants are female; private sector consultants have on average 3.58 patents while non-consultants have .94 patents. \*\*\* (\*\*, \*) indicate a significance level of 1% (5%, 10%).

### 3.3. Consulting and research outcomes (link 2)

The impact of consulting activities on academic research outcomes including scientific publications, research agenda setting, collaborative research or probability to exit from academia has been subject to intense public debate<sup>1</sup>, but is studied less frequently.

Few empirical studies directly test the relationship between consulting activities and scientific publications. Rebne (1989) finds a positive relationship between consulting activity and research productivity at low to moderate levels for all disciplinary groups except of the humanities. Also Mitchell and Rebne (1995) argue that moderate amounts of consulting (up to four hours per week) generally facilitate researchers' productivity instead of distracting them from research. More recently, Rentocchini et al. (2013) find a negative effect of academic consulting on ISI-publication output if consulting takes a considerable share of the researchers' time. However, they also point to field differences by showing that the negative effects occurs in natural and exact sciences and engineering but not in social sciences and humanities.

A closely related stream of research studies the effects of research income on research productivity. Especially sponsorship from the private sector may result from consulting projects and therefore indirectly reflect a researcher's engagement in consulting activities.

While some 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; Banal-Estañol and Macho-Stadler, 2010), others point to a potential brain drain leading to fewer publications or fewer citations per paper (Hottenrott and Thorwarth 2011, Banal-Estanol et al. 2015). Several studies conclude that a lower publication output of industry-sponsored researchers may be explained by delay and secrecy (Blumenthal et al, 1996; Florida and Cohen, 1999; Krinsky, 2003; Czarnitzki et al., 2014) or firms' impact on research agendas (Etzkowitz and Webster, 1998; Vavakova, 1998; Geuna, 1999; Hottenrott and Lawson 2014).

Finally, researchers may leave academe 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). Additionally, the socialization environment within a certain department may affect researchers' preferences for academic research compared to private sector work. Hottenrott and Lawson

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<sup>1</sup> See, for instance, Erk and Schmidt (2014) or OECD (2015)

(2014) show, for instance, that consulting active departments are more likely to see departing researchers move to the private sector.

The following analysis therefore explicitly considers the probability of exit from academe as a potential outcome (dropout). Also, the relationship between consulting and the number of publication ( $\text{publications}_{2006-2013}$ ) and the average number of citations per publication ( $\text{average citations}_{2006-2013}$ ) will be estimated conditional on being consulting active taking into account that research performance is path dependent consulting activities depend on previous research performance. Table 3 shows different research outcomes by type of consulting. The first outcome variable (dropout) is equal to one if the researcher had no ISI publication in the post survey period 2006 to end 2012. We see that in the group of private sector consultants, the share of dropouts is highest at about 37% (35% for public consultants) and lowest for non-consultants. Interestingly, dropout is also lower in the group of researchers who consult both the private and the public sector.

In terms of publication numbers in the post survey period, we see that those researchers that do both types of consulting published significantly more, but the average number of citations per paper published during that period is significantly lower for consulting-active researchers. These differences, however, are not persistent across disciplines. Figure 1 shows kernel density estimates of the publication and average citations distribution for the different types of consulting by research field. Whereas in social sciences, life sciences and natural sciences the distributions of non-consulting active researchers exceeds those of consulting active ones (this is revers among engineers). In social sciences the curves for private and public consulting largely overlap, but in life sciences the public consulting distribution is slightly above the one for private sector consultants. In natural sciences, the difference is more pronounced for publication numbers than for average citations per publication. Figure 2 shows the publication and citations distributions for the different types of consulting by academic rank. We see that among full professors the distributional differences are least pronounced. Non-consulting full professors only slightly outperform publication and average citation numbers of consulting actives ones. Among assistant professor and post docs, however, we see that the publication and average citation density of non-consulting actives ones exceeds those of consulting active almost over the entire distribution. The picture for researchers and senior researchers is similar.

Table 3: Descriptive statistics by type of consulting: research outcomes

	Full sample	Only private sector consulting	Only public sector consulting	Private and public sector consulting				No consulting
		I.	II.	III.	I vs. IV	II vs IV	III vs IV	IV.
	mean (sd)	mean (sd)	mean (sd)	mean (sd)	t-test	t-test	t-test	mean (sd)
# observations	983	129	168	138				548
dropout	.29 (.45)	.37 (.49)	.35 (.48)	.30 (.46)	***	***		.24 (.43)
publications <sub>2006-2013</sub>	15.75 (23.99)	14.50 (27.57)	14.18 (23.90)	20.28 (32.52)			**	15.38 (2.24)
average citations <sub>2006-2013</sub>	213.27 (510.31)	171.84 (411.47)	208.32 (751.43)	225.74 (455.55)	***	***	***	221.41 (45.55)
average citations <sub>2006-2013</sub>	7.77 (11.39)	5.91 (8.57)	6.10 (9.19)	6.05 (6.90)	***	***	***	9.16 (13.17)

Figure 2: Research outcomes by consulting type and discipline

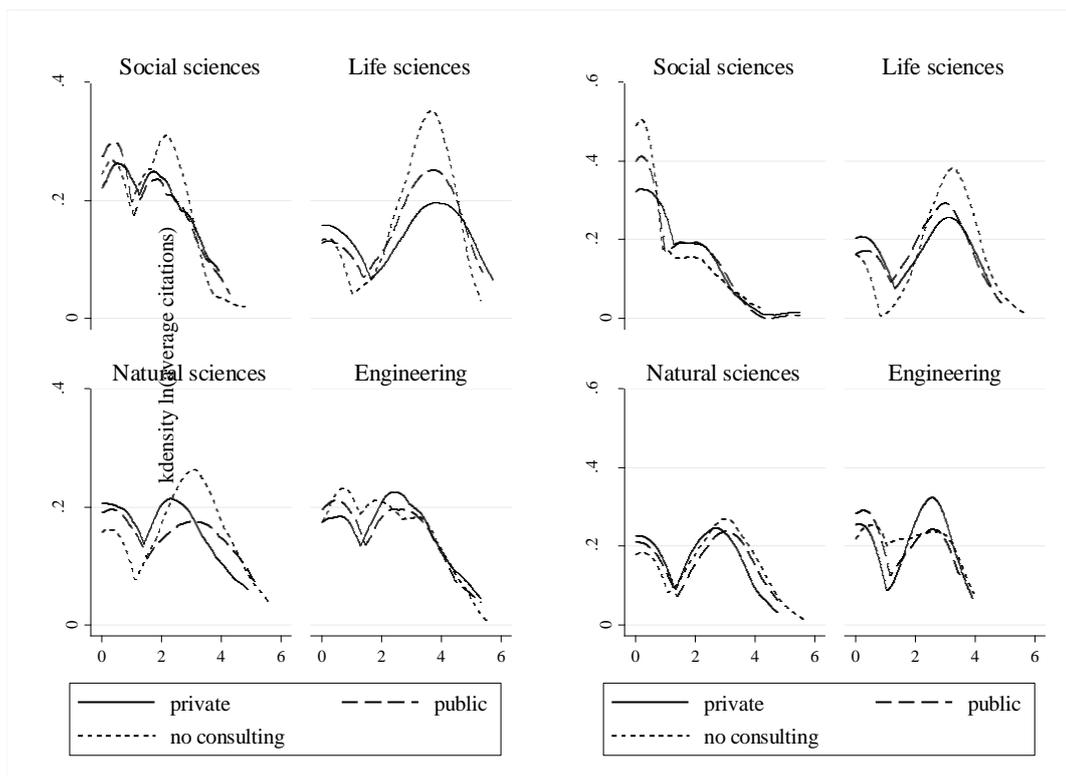
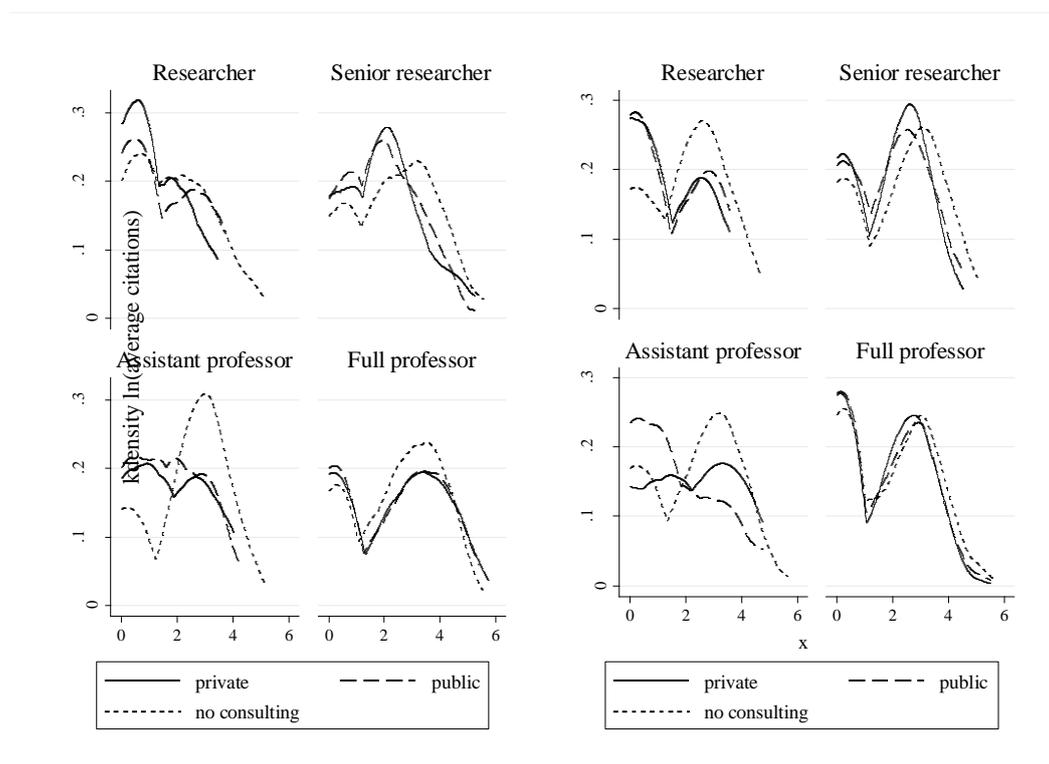


Figure 3: Research outcomes by consulting type and rank



### 3.4. Methodology

The following analysis proceeds in three steps. First, we estimate the consulting probability and the share in total time devoted to consulting activities and the different types of consulting using probit and tobit models. 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. The main dependent variables in the first step are the consulting dummies and time-shares.

Second, we estimate the effects of consulting activities on dropout from academic research. We account for the possibility of retirement and check the sensitivity of the results to the exclusion of individuals older than 63. We estimate probit models (with selection) for the likelihood of dropout conditional on engagement in consulting.

Third, we estimate endogenous switching models (see Lokshin and Sajaia, 2004) that account for the non-randomness of consulting activity in the effect of consulting on post-survey publication performance. We estimate separate models for consulting in general and the two types of consulting and for the two outcome variables publications and average citations per publication. Additionally, we account in each of these models for unobserved heterogeneity by using a specification as proposed by Blundell et al. (1995, 2002). In particular, we include the

log of a researchers pre-sample publication performance 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 scientist. For researchers without pre-sample publications, we include a dummy variable that takes the value one if the person had no publications in the pre-survey period.

## 4. Results

### 4.1. Factors influencing academic consulting ([link 1](#))

Table 4 shows the results from a set of probit models on the probability of engaging in consulting in general (models 1-4) and results from simultaneous probit models on public consulting and/or private sector consulting (models 5 and 6). We group the explanatory variables into individual, scientific, institutional and commercial attributes. We find that older researchers are more likely to engage in consulting, but the effects of age is twice as high for public consulting. Assistant professors are least likely to engage in consulting which may reflect high opportunity costs of such alternative activity compared to research.

In terms of scientific attributes, we see that ex-ante publication counts (model 2 and 5) and the average number of citations per publication (model 3, 4 and 6) are negatively correlated to consulting in general as well as to both types of consulting. Collaborative reach turns out to impact consulting probability positively, but this effect is driven by public sector consulting. International visibility does not explain consulting activities. Group leaders have a higher probability of engaging in consulting, but again the effect is driven by public sector consulting. University researchers are less likely to engage in consulting compared to researchers at public research organizations, but the effect is only significant for private sector consulting. On the other hand, multiply affiliated researchers are more likely to do public consulting.

Not surprisingly, commercial attributes correlate positively with private sector consulting. Correlations are smaller for public sector consulting with the exception of having experience in setting up a new venture, which correlates stronger with public sector consulting. Co-authorship with private sector employees, on the other hand, correlates only with private sector consulting and patenting researchers are less likely to do public consulting. In terms of scientific disciplines we find that the social sciences are most active in public consulting, while private sector consulting is more likely in engineering and life sciences compared to social sciences and natural sciences. The correlation between the public and private sector consulting equation is positive and significant, pointing to the importance of estimating these equations jointly.

The results from models 2 to 6, show that research performance in terms of publications and the average number of citations to these publication negatively correlates with consulting. In Table 5, we therefore present the results from the simultaneous probit models, in which we interact past publication (or citation) performance with the researcher's rank (model 7 and 8). These reveal that senior researchers, assistant professors and full professors mainly drive the negative ex-ante publication stock effect.

When accounting for the average number of citations, however, the negative selection also applies to full professors. When we differentiate the ex-ante publication performance by discipline, we see that the negative selection does not apply to all fields. For engineers, we see a positive association between prior publication numbers as well as citations and consulting. For public consulting, we see that the negative selection into consulting can be attributed to the natural sciences (results not presented). Overall, the negative association between prior publication performance and consulting is less pronounced for public consulting. In the simultaneous models, patenting is positively associated with industry consulting.

Table 4: Results of probit and simultaneous probit models on private and public sector consulting

Model	1	2	3	4	5	6		
Dependent variable	consulting	consulting	consulting	consulting	private consulting	public consulting	private consulting	public consulting
	df/dx (s.e.)	df/dx (s.e.)	df/dx (s.e.)	df/dx (s.e.)	df/dx (s.e.)	df/dx (s.e.)	df/dx (s.e.)	df/dx (s.e.)
<b>Personal attributes</b>								
age	.004* (.002)	.005** (.002)	.004* (.002)	.004** (.001)	.003*** (.001)	.006*** (.001)	.002** (.001)	.006*** (.001)
female	-.033 (.021)	-.027 (.022)	-.027 (.024)	.029 (.020)	-.023 (.017)	.062** (.030)	-.023 (.021)	.062** (.026)
researcher				Reference category				
senior researcher	-.015 (.020)	-.014 (.026)	-.009 (.025)	-.050** (.024)	-.008 (.021)	-.078*** (.027)	-.005 (.019)	-.077*** (.024)
assistant professor	-.146*** (.030)	-.142*** (.036)	-.123*** (.032)	-.159*** (.031)	-.089*** (.026)	-.139*** (.026)	-.079*** (.023)	-.133*** (.022)
full professor	.090 (.081)	.095 (.088)	.102 (.085)	.053 (.082)	.049 (.053)	.024 (.076)	.052 (.051)	.025 (.070)
<b>Scientific attributes</b>								
ln(publications <sub>pre2006</sub> )		-.035*** (.005)			-.024*** (.003)	-.019*** (.006)		
average citations <sub>pre2006</sub>			-.002*** (.000)	-.002*** (.001)			-.0011*** (.0003)	-.0007* (.0004)
collaborative reach		.030*** (.009)	.033*** (.009)	.022* (.011)	-.006 (.006)	.038** (.015)	-.004 (.006)	.038** (.016)
international visibility		-.001 (.068)	.014 (.073)	.082 (.054)	.138 (.107)	.037 (.052)	.146 (.110)	.044 (.055)
<b>Institutional attributes</b>								
group leader	.105** (.049)	.087** (.043)	.088* (.047)	.046 (.051)	-.020 (.040)	.069** (.027)	-.022 (.041)	.069** (.028)
university	-.135** (.061)	-.128** (.064)	-.137** (.062)	-.150*** (.056)	-.074*** (.023)	-.090 (.060)	-.076*** (.021)	-.094 (.059)
peer group size	.000* (.000)	.000* (.000)	.000* (.000)	.000 (.000)	.000 (.000)	.000 (.000)	.000 (.000)	.000 (.000)
multiple affiliation	.204*** (.052)	.196*** (.060)	.192*** (.057)	.162** (.079)	.039 (.047)	.183*** (.063)	.037 (.046)	.181*** (.061)
social sciences				Reference category				
life sciences	-.061 (.091)	-.052 (.083)	-.048 (.083)	-.138** (.068)	.007 (.026)	-.104* (.061)	.007 (.023)	-.106* (.063)
natural sciences	-.221*** (.043)	-.226*** (.039)	-.223*** (.040)	-.275*** (.041)	-.058 (.065)	-.195*** (.053)	-.056 (.063)	-.195*** (.054)
engineering	.047 (.040)	.050 (.043)	.035 (.041)	-.153*** (.042)	.071 (.063)	-.150*** (.035)	.060 (.066)	-.155*** (.034)
<b>Commercial attributes</b>								
techtransfer industry				.206*** (.026)	.269*** (.011)	.058*** (.022)	.266*** (.011)	.057*** (.021)
coauthorship industry				.118*** (.039)	.096*** (.037)	.064 (.060)	.091** (.037)	.061 (.058)
paid consulting industry				.293*** (.033)	.392*** (.028)	.043*** (.017)	.393*** (.028)	.043** (.017)
firm_d				.041*** (.002)	.040 (.025)	.070** (.035)	.038 (.024)	.070** (.034)
ln(patents)				.005 (.025)	.036** (.016)	-.065*** (.010)	.037** (.016)	-.063*** (.010)
Log pseudolikelihood	-627.12	-621.76	-619.69	-563.10	-6,516.67		-6,519.02	
Rho					.533*** (.058)		.539*** (.057)	

Number of observations: 983. \*\*\* (\*\*, \*) indicate a significance level of 1% (5%, 10%). All models contain a constant. Clustered standard errors in parenthesis.

Table 5: Results of simultaneous equation probit models on private and public sector consulting (with interactions)

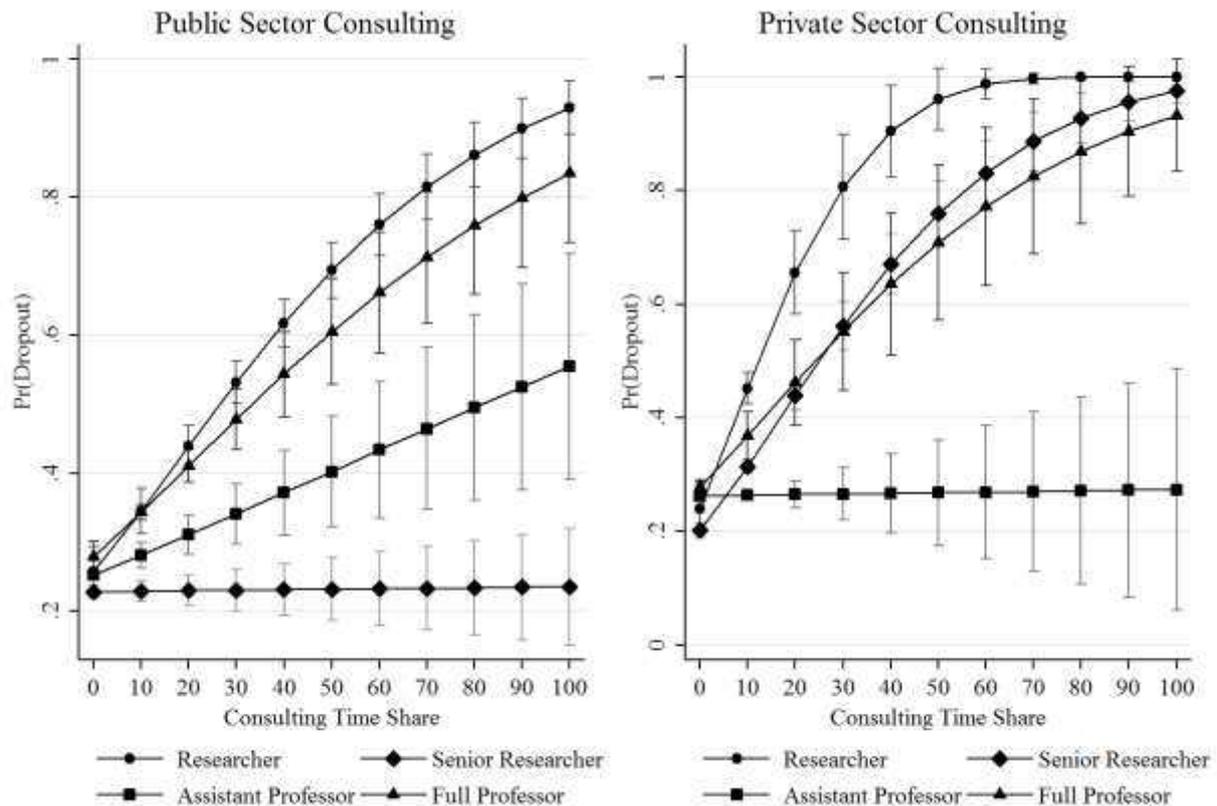
Model	7		8	
Dependent variable	private consulting coef. (s.e.)	public consulting coef. (s.e.)	private consulting coef. (s.e.)	public consulting coef. (s.e.)
<b>Personal attributes</b>			<b>Personal attributes</b>	
age	.009*** (.003)	.019*** (.004)	age	.007** (.003)
female	-.069 (.070)	.169* (.089)	female	-.072 (.085)
researcher	Reference	Reference	researcher	Reference
senior researcher	-.155* (.088)	-.240** (.096)	senior researcher	-.089 (.084)
assistant professor	-.532*** (.107)	-.486*** (.079)	assistant professor	-.397*** (.116)
full professor	.056 (.199)	-.039 (.199)	full professor	.143 (.191)
<b>Scientific attributes</b>			<b>Scientific attributes</b>	
ln(publications <sub>pre2006</sub> )	-.281*** (.019)	-.154*** (.010)	average citations <sub>pre2006</sub>	-.018*** (.003)
# researcher	Reference	Reference	# researcher	Reference
# senior researcher	.222*** (.018)	.034 (.021)	# senior researcher	.015*** (.003)
# assistant professor	.306*** (.017)	.059* (.035)	# assistant professor	.016*** (.003)
# full professor	.201*** (.019)	.137*** (.024)	# full professor	.013*** (.003)
collaborative reach	-.022 (.020)	.104** (.047)	collaborative reach	-.014 (.022)
international visibility	.469 (.378)	.106 (.149)	international visibility	.515 (.388)
<b>Institutional attributes</b>			<b>Institutional attributes</b>	
group leader	-.054 (.142)	.216** (.091)	group leader	-.070 (.139)
peer group size	.000 (.000)	.000 (.000)	peer group size	.000 (.000)
social sciences	Reference	Reference	social sciences	Reference
life sciences	.005 (.091)	-.319 (.196)	life sciences	.024 (.082)
natural sciences	-.213 (.246)	-.618*** (.188)	natural sciences	-.205 (.240)
engineering	.223 (.193)	-.493*** (.128)	engineering	.198 (.208)
university	-.255*** (.079)	-.258 (.172)	university	-.263*** (.071)
multiple affiliation	.135 (.149)	.499*** (.167)	multiple affiliation	.124 (.147)
<b>Commercial attributes</b>			<b>Commercial attributes</b>	
ln(patents)	.128** (.057)	-.189*** (.030)	ln(patents)	.128** (.057)
firm_d	.127 (.081)	.195** (.097)	firm_d	.127* (.076)
techtransfer industry	.908*** (.034)	.168** (.069)	techtransfer industry	.899*** (.041)
coauthorship industry	.307*** (.110)	.174 (.171)	coauthorship industry	.301*** (.116)
paid consulting industry	1.128*** (.070)	.117** (.047)	paid consulting industry	1.133*** (.071)
Log pseudolikelihood	-928.44		-928.20	
Rho	0.536*** (0.057)		0.541*** (0.056)	

Number of observations: 983. \*\*\* (\*\*, \*) indicate a significance level of 1% (5%, 10%). All models contain a constant. Clustered standard errors in parenthesis.

## 4.2. Outcomes of academic consulting (link 2)

Next, we are interested in the effects of consulting activities on ex-post publication performance. We first consider the extreme case of drop out, i.e. scientific publications in the post survey period. Figure 4 depicts the results from probit models on the likelihood of having zero publications in the post survey period. When looking at marginal effects (Figure 4, estimation results available upon request), we find that both types of consulting increase the likelihood of drop out at higher consulting time-shares. When differentiating by the researchers' positions, however, we see that in the case of public consulting this effect is largest for researchers, and significant, but smaller for assistant and full professors. For private sector consulting, we see that the drop out probability increases more sharply already at lower time-shares, in particular for researchers.

Figure 4: Predictive Margins on “drop-out”



Finally, we estimate the effect on the number of publications (and average citations per publication) in the post survey period. We find that compared to standard poisson models (which predict a negative effect of consulting on future research performance), the endogenous switching models take into account that the negative association is explained by the ex-ante lower publications numbers of consulting-active academics. For consulting in general, we find a weak

negative association between consulting time-share and publication numbers. This effect, however, disappears when only considering those who stay active. Distinguishing between private sector and public sector consulting shows that a higher private sector consulting share is associated with lower ex-post publication numbers, but that this effect levelling off for high times shares. For public sector consulting, we observe a small positive effect (Table 6). For ex-post average citations per publication, we see a negative relationship (but again, levelling off at high time shares) which remains significant even when excluding dropouts. Distinguishing by consulting type shows that the negative effect for private sector consulting disappears when dropouts are excluded and turns positive for higher values in the sample of “stayers”. Yet, public sector consulting that is only weakly significant in the full sample turns out negative and significant in the “stayers” sample (Table 7).

Table 6: Endogenous switching model on publication numbers

Model	1		2		3		4	
Dependent variable	ln(publications <sub>2006-2013</sub> )		ln(publications <sub>2006-2013</sub> )		ln(publications <sub>2006-2013</sub> )		ln(publications <sub>2006-2013</sub> )	
Group	no consulting	consulting	no consulting	consulting	no consulting	consulting	no consulting	consulting
	coef. (s.e.)	coef. (s.e.)	coef. (s.e.)	coef. (s.e.)	coef. (s.e.)	coef. (s.e.)	coef. (s.e.)	coef. (s.e.)
consulting share		-.017* (.010)		-.011 (.014)				
consulting share # consulting share		.00007 (.00008)		.00015 (.00017)				
private share						-.043*** (.010)		-.033 (.022)
private share # private share						.00031*** (.0001)		.001** (.000)
public share						-.003 (.009)		.004 (.016)
public share # public share						-.00005 (.0001)		-.00015 (.0002)
researcher		Reference		Reference		Reference		Reference
senior researcher	.285*** (.032)	.231** (.090)	.392*** (.035)	.137* (.076)	.284*** (.032)	.269*** (.098)	.391*** (.036)	.161* (.089)
assistant professor	.615*** (.108)	.309*** (.105)	.849*** (.101)	.276** (.123)	.619*** (.107)	.380*** (.128)	.848*** (.100)	.277*** (.098)
full professor	.445*** (.119)	.133 (.216)	.754*** (.123)	.293* (.171)	.441*** (.119)	.139 (.221)	.749*** (.118)	.283 (.175)
female	.143 (.106)	.011 (.042)	-.037 (.091)	-.269** (.123)	.144 (.107)	-.037 (.051)	-.036 (.091)	-.283*** (.110)
university	-.049 (.190)	.020 (.287)	-.239 (.182)	.123 (.259)	-.046 (.191)	.049 (.280)	-.236 (.179)	.156 (.267)
no publication <sub>pre2006</sub>	-.637*** (.098)	-1.006*** (.255)	-.008 (.067)	-.063 (.177)	-.638*** (.098)	-1.048*** (.228)	-.007 (.066)	-.114 (.187)
ln(publication <sub>pre2006</sub> )	.336*** (.035)	.342*** (.048)	.236*** (.024)	.259*** (.043)	.337*** (.035)	.327*** (.043)	.237*** (.024)	.247*** (.046)
no patent <sub>pre2006</sub>	-.066 (.249)	-.393 (.287)	.053 (.271)	-.315 (.283)	-.066 (.249)	-.393 (.323)	.051 (.269)	-.302 (.315)
ln(patent <sub>pre2006</sub> )	.106 (.082)	.030 (.063)	.102 (.072)	-.018 (.242)	.103 (.080)	.046 (.067)	.099 (.070)	-.001 (.255)
eu funding	-.297*** (.085)	.024 (.041)	-.208 (.139)	-.097 (.076)	-.298*** (.085)	-.020 (.048)	-.208 (.138)	-.129* (.074)
gov. funding	.175 (.143)	-.069 (.194)	.105* (.056)	.022 (.124)	.175 (.143)	-.126 (.175)	.104* (.055)	-.022 (.106)
scientific funding	.245 (.182)	.612*** (.066)	.510*** (.084)	.827*** (.075)	.241 (.182)	.552*** (.061)	.509*** (.086)	.787*** (.088)
industry funding	.332 (.206)	-.135 (.180)	.124 (.194)	-.351** (.141)	.326 (.214)	.065 (.171)	.125 (.196)	-.289 (.204)
other funding	.344 (.616)	.049 (.054)	.428*** (.058)	.063 (.078)	.343 (.615)	-.017 (.066)	.429*** (.057)	.098 (.066)
social sciences		Reference		Reference		Reference		Reference
natural sciences	.757*** (.070)	.387*** (.084)	.789*** (.106)	.682*** (.126)	.762*** (.067)	.472*** (.047)	.790*** (.109)	.779*** (.138)
life sciences	.779*** (.076)	.338*** (.047)	.902*** (.110)	.792*** (.075)	.777*** (.072)	.392*** (.081)	.901*** (.110)	.830*** (.100)
engineering	.302 (.207)	.144 (.136)	.194 (.166)	.305*** (.033)	.299 (.206)	.259*** (.093)	.192 (.164)	.392*** (.066)
# observations	983		700		983		700	
Log likelihood	-2,066.56		-1,238.28		-2,062.96		-1,236.84	
/r0	-.467*** (.142)		-.477*** (.131)		-.490*** (.132)		-.490*** (.147)	
/r1	-.228*** (.062)		-.450*** (.144)		-.357*** (.021)		-.683** (.304)	

\*\*\* (\*\*, \*) indicate a significance level of 1% (5%, 10%). Selection stage not presented. Exclusion restrictions: 1-4 significant at 1% level in the first stage.

Table 7: Endogenous switching model on average citations

Model	1		2		3		4	
Dependent variable	average citations <sub>2006-2013</sub>		average citations <sub>2006-2013</sub>		average citations <sub>2006-2013</sub>		average citations <sub>2006-2013</sub>	
Group	no consulting	consulting	no consulting	consulting	no consulting	consulting	no consulting	consulting
	coef. (s.e.)	coef. (s.e.)	coef. (s.e.)	coef. (s.e.)	coef. (s.e.)	coef. (s.e.)	coef. (s.e.)	coef. (s.e.)
consulting share		-.014*** (.004)		-.032*** (.008)				
consulting share # consulting share		.00008*** (.00002)		.00077** (.00035)				
private share						-.024*** (.006)		-.020 (.020)
private share # private share						.00018* (.00009)		.00085*** (.00028)
public share						-.006* (.003)		-.017*** (.004)
public share # public share						.000009 (.00003)		.00043*** (.00016)
researcher	Reference		Reference		Reference		Reference	
senior researcher	-.177*** (.020)	.387*** (.029)	-.196*** (.060)	.340*** (.040)	-.177*** (.020)	.398*** (.066)	-.196*** (.061)	.356*** (.029)
assistant professor	-.075 (.125)	.393*** (.070)	-.159* (.086)	.253*** (.051)	-.073 (.125)	.417*** (.098)	-.159* (.085)	.208*** (.049)
full professor	-.429*** (.068)	.157** (.073)	-.356*** (.039)	.218** (.093)	-.428*** (.068)	.152 (.102)	-.356*** (.039)	.225** (.098)
female	.007 (.048)	-.070 (.125)	-.183** (.077)	-.261* (.146)	.008 (.048)	-.092 (.136)	-.183** (.076)	-.250* (.144)
university	.179 (.124)	-.115 (.139)	-.007 (.116)	-.128 (.115)	.180 (.125)	-.101 (.138)	-.007 (.116)	-.110 (.116)
no average citations <sub>pre2006</sub>	.264** (.120)	-.257 (.191)	.595*** (.100)	.347*** (.093)	.264** (.120)	-.274 (.172)	.594*** (.099)	.359*** (.077)
ln(average citations <sub>pre2006</sub> )	.483*** (.030)	.365*** (.042)	.337*** (.030)	.312*** (.025)	.483*** (.031)	.359*** (.038)	.337*** (.030)	.315*** (.021)
no patent <sub>pre2006</sub>	-.070 (.072)	-.298 (.332)	-.026 (.159)	-.421 (.315)	-.071 (.072)	-.297 (.341)	-.026 (.160)	-.417 (.336)
ln(patent <sub>pre2006</sub> )	-.126 (.169)	-.094 (.116)	-.145 (.089)	-.262 (.206)	-.127 (.169)	-.086 (.118)	-.145 (.088)	-.247 (.224)
eu funding	-.142*** (.029)	.071 (.050)	-.052 (.215)	.040 (.064)	-.143*** (.029)	.054 (.046)	-.052 (.216)	.039 (.071)
gov funding	.038 (.119)	-.010 (.155)	.063 (.211)	.067 (.097)	.038 (.119)	-.038 (.145)	.063 (.211)	.057 (.089)
scientific funding	-.084 (.127)	.111 (.092)	.145 (.113)	.157 (.108)	-.084 (.127)	.087 (.083)	.145 (.113)	.179 (.117)
industry funding	.132 (.134)	.077 (.196)	-.008 (.188)	.095 (.196)	.133 (.133)	.167 (.145)	-.008 (.189)	-.009 (.232)
other funding	-.019 (.484)	.059 (.104)	.160*** (.055)	.069 (.138)	-.019 (.486)	.027 (.080)	.160*** (.055)	.123 (.144)
social sciences	Reference		Reference		Reference		Reference	
natural sciences	1.034*** (.202)	.272*** (.055)	1.229*** (.218)	.528*** (.057)	1.035*** (.201)	.314*** (.071)	1.230*** (.216)	.533*** (.100)
life sciences	.852*** (.142)	.173*** (.044)	1.333*** (.145)	.440*** (.073)	.852*** (.142)	.198*** (.043)	1.333*** (.144)	.447*** (.071)
engineering	.569*** (.143)	.082 (.091)	.826*** (.072)	.217*** (.051)	.569*** (.144)	.133** (.061)	.826*** (.071)	.216*** (.054)
# observations	983		700		983		700	
Log likelihood	-1,880.1539		-1,181.64		-1,879.04		-1,181.46	
/r0	-1.173*** (.298)		-.582 (.448)		-1.177*** (.297)		-.583 (.443)	
/r1	.020 (.176)		.111 (.352)		-.043 (.171)		.107 (.468)	

\*\*\* (\*\*, \*) indicate a significance level of 1% (5%, 10%). Selection stage not presented. 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. Investigating private sector as well as public sector consulting activities in a sample of researchers at universities and public research organizations in Germany, we find that personal, institutional and scientific attributes explain much of the variation in consulting activities. Private sector consulting is also associated with other channels of university-industry technology transfer like patenting and co-authoring with private sector employees. While private sector consulting is more common among engineering scientists, public sector consulting is more common in the social and life sciences. While overall there is a negative correlation between ex-ante research performance and consulting, this relationship reverses for engineers. For public consulting, we observe that researchers with a wider collaborative network and multiple affiliations are more often engaged in consulting. This points to reputation effects which are not directly related to ex-ante performance in terms of scientific publications.

We also stress the importance of accounting for the selection into consulting when studying its impact on future research performance. Results from endogenous switching models show that while generally less productive researchers engage in consulting, it does not further reduce, but in the case of private sector consulting, even slightly increases their research performance ex-post. Not taking into account the selection would lead to a misinterpretation of the selection effect as outcome effect. However, we do see that, especially in the case of private sector consulting, a higher share of time devoted to consulting increases the probability of drop out from academic work. This effect is strongest for lower rank researchers, but also significant for tenured faculty. In case of public sector consulting, we see lower average citations per paper in the ex-post period. This may indicate that those scientists who remain research-active engage in different types of research, for instance in more applied research or more context-specific research.

These results contribute to the debate on academic consulting as a channel of knowledge and technology transfer. While we do see that in all disciplines, but engineering, the less productive researchers do most of the consulting, we cannot confirm concerns related to a potential detrimental effect of consulting on future research performance. Yet, for researchers in earlier stages of their academic career consulting activities may lead to alternative career paths outside academe.

We encourage further research on academic consulting that also takes into account the monetary rewards. While paid consulting in the form of contract research may increase the researchers'

institutional research budget 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 distinguish the contractual mechanism in future work.

## Appendix

Table A1: Literature link 1

Authors	Country	Type of consulting	Thematic Focus	Academic fields	Influencing Factors
Martinelli et. al. (2008)	UK	general	knowledge exchange relationships of entrepreneurial faculty	Humanities, Life Sciences, Social Sciences and Cultural Studies, Science and Technology	SciTech School faculty prefer consultancy arrangements
Landry et al. (2010)	CA	general	Knowledge Transfer Activities	Chemistry, Computer Sciences, Earth Sciences, Life Sciences, Engineering	spin-off creation, informal knowledge transfer, publications, private funding, network assets, research unit size, large research universities, engineering
D'Este et al. (2013)	ES	general	Academic Consulting	Agricultural, biological and medical sciences, Social sciences, Humanities, Mathematics and physics, Engineering and technology	amount of contract funding, international competitive funding
Haeussler and Colyvas (2011)	DE, UK	general	Academic Entrepreneurship	Life sciences (biochemistry, cell biology, developmental biology, genetics, proteomics, immunology, microbiology, Neurosciences, clinical medicine, oncology, pharmaceutical sciences, bioinformatics, bioprocess engineering, veterinary, plant sciences	reputational value of academic achievement, spin-off
Rentocchini et al. (2013)	ES	general	Academic Consulting	Natural and Exact Sciences, Engineering, Social Sciences , Humanities	Number of research projects, by competitive funding for research, being a lecturer, higher levels of experience, more applied disciplines like engineering and technology.
Louis et al. (1989)	US	Private sector	Academic Entrepreneurship	Life sciences (biochemistry, molecular biology, genetics, microbiology, biology, cellular biology, or botany)	Age, arts and sciences departments, other entrepreneurial behaviours
Link et al. (2007)	US	Private sector	Informal Technology Transfer	various fields of science and engineering	male, tenured, research-grant active
Boardman and Ponomariov (2009)	US	Private sector	scientists' interactions with the private sector	Engineering, Physical Sciences Agriculture, Computer Science	industry grants, tenure, commercial attitude
Grimpe and Fier, (2010)	DE	Private sector	Informal technology transfer	Social sciences and humanities, Life sciences, Other natural sciences, Engineering sciences	Gender, heading a research group, size of the peer group
Perkmann et al. (2011)	UK	Private sector	Academic Engagement	Physical and Engineering, Medical and Biological Sciences, Social Sciences, Arts and Humanities, Languages and Area Studies	top-ranked researchers
D'Este and Perkmann (2011)	UK	Private sector	Academic Engagement	Physical and Engineering (Chemical Engineering, Chemistry, Civil Engineering, Computer Science, Electrical and Electronic Engineering, General Engineering, Mathematics, Mechanical, Aeronautical and Manufacturing Engineering, Materials and Metallurgy, Physics)	research-related motivation, age, lower-rated research departments
Amara et al. (2013)	CA	Public and private sector	Academic Consulting	Natural Sciences, Engineering	industry funding, size of research laboratories, large-sized research universities, technical validation of knowledge, protection of IP, strong ties with people in companies and teaching

Table A2: Scientists' division of time

		Research	Research funded by research grants	Teaching	Administration	Private Sector Consulting	Public Sector Consulting
	obs.	mean (sd)	mean (sd)	mean (sd)	mean (sd)	mean (sd)	mean (sd)
<b>Full sample</b>	<b>983</b>	<b>32.02 (22.76)</b>	<b>19.90 (2.96)</b>	<b>21.44 (16.76)</b>	<b>21.16 (16.41)</b>	<b>2.34 (6.43)</b>	<b>3.13 (8.04)</b>
<b>By Position</b>							
researcher	94	31.36 (31.14)	34.81 (32.51)	9.31 (16.59)	17.54 (21.96)	1.61 (3.95)	5.37 (15.90)
senior researcher	253	4.75 (24.62)	22.21 (22.70)	9.32 (1.42)	21.08 (19.22)	3.38 (9.01)	3.26 (7.82)
assistant professor	108	37.44 (26.46)	22.63 (23.04)	21.33 (14.75)	15.00 (14.07)	1.48 (6.94)	2.11 (6.56)
full professor	528	26.85 (17.10)	15.58 (14.68)	29.44 (14.77)	23.09 (13.64)	2.16 (4.98)	2.88 (6.05)
<b>By Discipline</b>							
Social Sciences	209	24.584 (23.585)	22.191 (2.255)	27.888 (18.514)	19.352 (14.993)	1.746 (5.639)	4.239 (8.169)
Life Sciences	290	34.438 (22.154)	19.283 (21.759)	18.814 (14.435)	21.886 (16.178)	2.045 (6.996)	3.534 (7.956)
Natural Sciences	301	31.880 (22.058)	22.322 (23.584)	2.851 (16.690)	21.708 (18.169)	1.297 (3.449)	1.942 (5.768)
Engineering	183	36.934 (21.916)	14.273 (13.596)	19.224 (16.431)	21.153 (15.192)	5.224 (8.863)	3.191 (1.630)

Table A3: Literature link 2

Authors	Country	Thematic focus	Academic field	Findings
Rentocchini et al. (2013)	ES	Scientific Publications	Natural and Exact Sciences, Engineering, Social Sciences Humanities	academic consulting has a negative effect on scientific productivity; distinct effects at different degrees of consulting activity, no significant effect below median and negative above median
Rebne (1989)	US	Scientific Publications	Engineering, Agricultural and veterinary science, Management, Education, Social sciences, Biological sciences, Natural sciences, Humanities	Applied fields (engineering, education, management) are most active in consulting, positive relation with research productivity, slight decline only above 13 hours of consulting; in engineering 5-8 h consulting raised productivity by one quarter
Mitchell and Rebne (1995)	US	Scientific Publications	Engineering, Agricultural and veterinary science, Management, Education, Social sciences, Biological sciences, Natural sciences, Humanities	Positive effect of consulting on research productivity, up to 4 hours per week of consulting are facilitative of research productivity

Table A4: Simultaneous equation tobit models (time-shares, 983 obs.)

Model	5		6	
Dependent variable	private consulting share	public consulting share	private consulting share	public consulting share
	coef. (s.e.)	coef. (s.e.)	coef. (s.e.)	coef. (s.e.)
<b>Personal attributes</b>				
age	-.009 (.018)	.022 (.033)	-.016 (.018)	.016 (.034)
female	.406 (.381)	1.525*** (.581)	.414 (.408)	1.537** (.604)
researcher		Reference category		
senior researcher	1.319*** (.314)	-2.100*** (.637)	1.274*** (.317)	-2.148*** (.625)
assistant professor	.891** (.398)	-2.201*** (.774)	.895** (.391)	-2.219*** (.749)
full professor	1.096* (.610)	-.896 (1.146)	1.028* (.609)	-.967 (1.141)
<b>Scientific attributes</b>				
ln(publications <sub>pre2006</sub> )	-.275*** (.042)	-.251*** (.067)		
average citations <sub>pre2006</sub>			-.002 (.003)	-.001 (.002)
collaborative reach	-.106 (.078)	-.140 (.253)	-.128* (.071)	-.163 (.247)
international visibility	-2.427** (1.039)	-3.575 (3.646)	-2.398** (1.039)	-3.552 (3.645)
<b>Institutional attributes</b>				
group leader	-.842 (.528)	.784* (.434)	-.814 (.537)	.808* (.445)
university	-1.482*** (.411)	-3.036*** (.520)	-1.508*** (.396)	-3.060*** (.532)
peergroup size	.003 (.003)	.001 (.001)	.003 (.003)	.001 (.001)
multiple affiliation	.327 (.379)	3.716*** (.637)	.323 (.350)	3.718*** (.615)
social sciences				
life sciences	-.512 (.749)	-.768 (.673)	-.712 (.751)	-.973 (.695)
natural sciences	-.911 (.593)	-2.472*** (.482)	-1.017* (.587)	-2.580*** (.497)
engineering	1.338* (.754)	-1.239 (1.707)	1.247 (.796)	-1.324 (1.724)
<b>Commercial attributes</b>				
techtransfer industry	1.852*** (.537)	.898 (.751)	1.869*** (.552)	.922 (.753)
coauthorship industry	.568 (.512)	.615 (1.018)	.555 (.514)	.607 (1.013)
paid consulting industry	3.841*** (.572)	-.494 (.493)	3.832*** (.570)	-.503 (.499)
firm_d	2.064*** (.790)	.823 (.536)	2.085*** (.803)	.845 (.516)
ln(patents)	-.045 (.457)	-.906* (.515)	-.042 (.467)	-.906* (.527)
Log likelihood	-6,516.67		-6,519.02	
Rho_12	-.021		-.019	

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