Scientometrics
DOI 10.1007/s11192-017-2280-7

Identity and publication in non-university settings: academic co-authorship and collaboration

Therese Kennelly Okraku[1] · **Raffaele Vacca**[1] · **James W. Jawitz**[2] · **Christopher McCarty**[1]

Received: 23 September 2016
© Akadémiai Kiadó, Budapest, Hungary 2017

Abstract Increased collaboration between researchers working in university, industry, and governmental settings is changing the landscape of academic science. Traditional models of the interaction between these sectors, such as the triple helix concept, draw clear distinctions between academic and non-academic settings and actors. This study surveyed scientists ($n = 469$) working outside of university settings who published articles indexed in the Web of Science about their modes of collaboration, perceptions about publishing, workplace characteristics, and information sources. We study the association between these variables, and use text analysis to examine the roles, duties, sites, topics, and workplace missions among non-university based authors. Our analysis shows that 72% of authors working in non-university settings who collaborate and publish with other scientists self-identify as academics. Furthermore, their work life resembles that of those working in university settings in that the majority report doing fundamental research in government research organizations and laboratories. Contrary to our initial hypothesis, this research suggests that peer-reviewed publications are much more dominated by non-university academics than we previously thought and that collaboration as co-authors on academic publications is not likely to be a primary conduit for the transfer of scientific knowledge between academe and industry.

Keywords Collaboration · Academia · Publishing · Knowledge transfer

Electronic supplementary material The online version of this article (doi:10.1007/s11192-017-2280-7) contains supplementary material, which is available to authorized users.

✉ Therese Kennelly Okraku
therese@ufl.edu

[1] Bureau of Economic and Business Research, University of Florida, Gainesville, FL, USA

[2] Soil and Water Science Department, University of Florida, Gainesville, FL, USA

Published online: 06 February 2017

Introduction

Scientists working in non-university settings are expanding the landscape of academia. Traditionally, the title of an academic has been reserved for faculty working in university settings (Altbach 1996, 1997; Clark 1997). Academic identity has been tied to individual autonomy, physical location, disciplinary training, and occupation (Kogan 2000; Henkel 2005). This work asks whether a more meaningful, broader notion of academic researcher can be defined, based on behavior and self-identification rather than occupational title or work location. We argue that such a notion would help to improve our understanding of the pathways of innovation and knowledge transfer between government, universities and industry.

Our initial purpose for this study was to estimate the proportion of authors who publish in the Web of Science (WoS) that work in non-academic settings and to document their workplace conditions and motivations for publishing. Our hypothesis was that publishing collaborations served as a vehicle for knowledge diffusion between university and non-university settings.

This paper uses quantitative and qualitative survey data to characterize the scientists who work in non-university settings. First, we will provide a brief overview of the literature on innovation transfer and scientific collaboration. Second, we will describe our sampling method and the quantitative and qualitative data analysis methodology. Third, we will report descriptive statistics from the survey and test the association between respondents' self-identification as an academic and their level of collaboration, publishing perceptions, workplace characteristics, and information sources. Fourth, we highlight common themes in respondents' job and workplace characteristics identified through text analysis. We will then conclude the paper with a discussion of these results and suggestions for further research on scientists working in non-university settings.

Literature review

The Oxford English Dictionary defines an academic as, "A member of a university or college, now specifically a senior member, a member of a university or college's teaching or research staff. Also in weakened sense: a person interested in or excelling at pursuits involving reading, thinking, and study" (OED Online 2016). This definition highlights the central role that the university plays in grounding academic identity both as a workplace location and source of employment. It also provides room for individuals to self-identify as academics through their individual research pursuits. The university has traditionally been conceptualized by philosophers like Wilhelm von Humboldt and John Henry Newman as a site of both research and educational studies centered primarily around preparing the next generation of global citizens (Schimank and Winnes 2000; Kogan 2000). However, recently there have been critiques of the corporatization of higher education and shift towards viewing universities as preparing students for the workplace. Specially, Henkel (2005) found that the corporatization of higher education, increases in administrative and teaching duties, reduction in academic autonomy, and decreases in governmental funding for research has led many scientists to move from universities to research centers. This paper also applied the communitarian moral philosophy and symbolic interactionism theories to examine how academic communities are formed through disciplinary training

and specialization. This paper builds upon Henkel's findings and examines the identities of academics working in non-university settings.

Historical models of research and innovation depicted uni-directional flows of funding and innovation between government, academe and industry (e.g., Pavitt and Walker 1976). In this model, (1) the state provides research funding to academia, (2) academia does research and transfers this knowledge to industry through academic publications, and (3) industry uses this knowledge to create innovative products that have societal benefits, which leads to the government providing additional financial resources. This model has been largely supplanted by the Triple Helix concept (see Etzkowitz and Leydesdorff 1995; Leydesdorff and Meyer 2007) wherein all three sectors (government, academe and industry) play roles at different levels with multi-directional flows of knowledge, financial resources, and societal benefits. Research funding may be provided by both the government and industry, with the government likely providing a larger share. All three institutions are involved in research, academics perhaps more so, and all three are similarly involved in knowledge transfer and innovation application, with industry focusing on this sector and articulating consumer demand.

In both traditional models and newer conceptual formulations, academics and non-academics are defined based on traditional occupational and locational terms. Collaboration and the transfer of innovation between universities, governments, and companies can occur through a variety of mechanisms, including publications (Butcher and Jeffrey 2005), consulting (Agrawal 2001), patents (Bhattacharya and Meyer 2003), conference attendance (Geuna and Muscio 2008), and the exchange of human or physical resources. This paper focuses on knowledge transfer and innovation occurring through scientific collaboration between university and non-university actors on peer-reviewed publications.

Publications have long been the predominant measure of scientists' productivity (de Solla Price 1965). Publishing increases researchers' opportunities for employment, grants, and access to equipment, space, and technical assistance (McMillan and Hamilton 2000). It also enhances their reputation in the scientific community by increasing their visibility and the impact of their research impact (Merton 1973, Nelson 1990). Collaborative research is increasingly recognized as an important part of the generation and dissemination of scientific findings. Research collaborations are often studied by analyzing co-authored publications (Beaver and Rosen 1978; Börner et al. 2005; Katz and Martin 1997) and collaborations among institutional sectors (Abramo et al. 2009; Butcher and Jeffrey 2005; Frenken et al. 2005).

The prevalence of corporate publications and co-authored publications between industry and academia varies by company, sector, and country, as well as by focus on applied versus basic scientific production (Belkhodja and Landry 2007; Butler and Visser 2006; Zhao 2005). Studies have also assessed the motivations for non-academics to publish and apply to grants with academics despite their different work obligations (Belkhodja and Landry 2007). Publishing may help companies by improving the quality of their research; gaining a reputation for performing high quality basic science; establishing intellectual claims and legal rights; attracting first-rate researchers and technicians, customers, capital, partners, and suppliers; and creating self-monitoring and evaluation tools (Godin 1996; Godin et al. 1995; Hicks 1995). There is a vast literature on university-industry relations around the world (Abramo et al. 2009; Belkhodja and Landry 2007; Lundberg et al. 2006). However, most of these studies are based on quantitative analysis of secondary data, such as citation or patent analysis, from one or two locations. By contrast, this paper uses primary quantitative and qualitative survey data to examine university, government, and industry collaboration without a geographic boundary.

Data and methods

The data used in this study are from an online survey conducted to describe the motivations and workplaces of WoS publication authors who work in non-university settings. The survey was completed in 2007 as part of a multi-faceted initiative to examine multi-disciplinary publication and collaboration patterns (Hopkins et al. 2013; McCarty and Jawitz 2013a, b). The survey was completed by 752 respondents and asked 38 questions about the respondent's collaborative behavior, perceptions of publications, workplace characteristics, and knowledge sources.

The sampling frame for survey respondents was developed as follows. All unique author/affiliation combinations for the year 2006 were downloaded from the WoS, totaling 3,004,946 unique records. Our assumption was that authors were either academics, affiliated with a university, school or college, or non-academics, affiliated with a government agency or private companies. Being interested in the latter subset of authors, we filtered out all records whose affiliation contained the strings "univ" (for "university" or similar terms), "sch" (for "school" or similar), or "coll" (for "college" or similar). The filter resulted in 1,084,833 records being extracted out of the original data. Among the extracted records, a subset of 20,000 records was randomly selected, and an attempt was made to find an e-mail address for each author in the subset. Email addresses for 7962 authors were found and sent an email invitation and up to two reminder emails to participate in the online survey.

The survey was completed by 752 respondents with a response rate of 9.4%. We acknowledge that this response rates is low. However, we believe that it is within an acceptable range because this was a difficult population to sample and web surveys typically have lower response rates that paper surveys (Fan and Yan 2010). Of the 752 respondents, 4 were excluded because they indicated that they had not authored or coauthored a published article, and 279 were excluded because they reported that they actually did work at a college or university. This divergence between the affiliation authors listed on their publications and where they report working could also have influenced the response rate. The remaining 469 respondents constitute the sample of all analyses in this paper.

Data analysis

Closed-ended questions were analyzed using SPSS (2013) and R (2008). Descriptive statistics were performed for all questions to examine demographics, education and work, and workplace characteristics (Table 1); workplace collaboration culture (Table 2); motivations and rating for collaborating with academics or universities for research (Table 3); collaboration experiences (Table 6 in Electronic supplementary material). A Chi square test was used to test if there was a relationship between whether a respondent self-reported as an academic and four categorical variables (level of collaboration, publishing perceptions, workplace characteristics, and information sources – Tables 7 and 8 in Electronic supplementary material).

Since all survey respondents worked in organizations other than universities, we initially conceptualized them as non-academic authors. However, our survey included a question asking whether the respondent considered him or herself to be an academic. We were initially surprised to find that the majority of respondents (72%) self-identified as

Table 1 Demographics and workplace characteristics

	n	%	Mean	SD
Demographics				
Sex				
Female	82	17.5		
Male	377	80.4		
Prefer not to answer	10	2.1		
Total	469	100		
Age	439		48.4	9.93
Race				
White	351	74.8		
Black	4	0.9		
Asian	60	12.8		
Native American	2	0.4		
Pacific Islander	2	0.4		
Multi-racial	4	0.9		
Other	7	1.5		
Don't Know	2	0.4		
Prefer not to answer	37	7.9		
Total	469	100		
Location				
Within USA	153	32.6		
Outside USA	302	64.4		
Don't know	2	0.4		
Prefer not to answer	12	2.6		
Total	469	100		
Education and work				
Year earned their highest degree	461		1992	10.8
Years worked at current institution or company	465		15.3	10.2
Hours worked per week	462		49.7	11.8
Hours devoted to working on publications per week	434		21.1	19.3
Percentage of time devoted to publications	415		0.376	0.29
Number of employees they supervise	436		14	49.8
Would you prefer a position in a college or university?				
Yes	86	18.3		
No	191	40.7		
Maybe	133	28.4		
Don't Know	32	6.8		
Prefer not to answer	12	2.6		
Total	454	100		
Workplace characteristics				
Number of people employed at their location	425		1514	3902
Type of workplace				
National government	238	50.7		
Not-for-profit non-government organization	90	19.2		

Table 1 continued

	n	%	Mean	SD
For-profit company	62	13.2		
State/Provincial government	33	7		
Local government	3	0.6		
Other	38	8.1		
Prefer not to answer	4	0.9		
Don't Know	1	0.2		
Total	469	100		

academics. As a result, we used a Chi square test to examine the relationship between an author's self-identification as an academic and four author characteristics we had identified during the development of the survey questionnaire. Self-perception as an academic is conceptualized as the main outcome variable in the following quantitative analysis. We studied the association between this variable and a number of author characteristics on four main dimensions:

(i) *Level of collaboration*: Whether respondents collaborated with academic researchers in the past five years, and how frequently they currently talk to academic researchers.
(ii) *Perceptions about peer-reviewed publications*: Whether respondents perceived that working on publications for a peer-reviewed journal was a good use of their time and their organization's budget.
(iii) *Workplace characteristics*: The mission of the organization to which authors were affiliated, the interactions of this organization with universities, and expectations and resources that the organization devoted to publishing.
(iv) *Information sources*: Whether respondents routinely read peer-reviewed journal articles, and to what extent they drew ideas from academic articles that could be applied to their work.

Categorical variables in each of the four dimensions are cross-tabulated with the academic self-perception binary variable. Chi square tests are conducted to study the significance and direction of the association between row and column variables. We use Pearson's standardized residual to examine the association between specific row and column categories.

Open-ended text responses were analyzed in MAXQDA (qualitative data analysis software, 1986–2016) using an inductive grounded theory approach (Glaser and Strauss 2009; Ryan and Bernard 2003). Repetitive themes were identified through reading through responses and sorting them into categories and subcategories. Most responses highlighted more than one theme and were coded into multiple categories. Therefore, the code percentages are not equal to 100%. Two coders analyzed the data to generate common themes, create code definitions, and code the qualitative data. Qualitative data analysis was performed for two questions to examine respondents' other motivations for collaborating with academics for research (Table 4) by workplace type (Table 5 in Electronic supplementary material) and identify themes in respondents' job and workplace characteristics (Tables 9–14 in Electronic supplementary material).

Table 2 Chi square test of association between identifying as an academic and level of collaboration/perceptions about publications

Do you consider yourself to be an academic?	Yes	No	Total
	326 (72%)	129 (28%)	455 (100%)
Collaboration			
Over the past five years, have you had professional collaborations with academic scientists?			
Yes	314 (97%)*	110 (85%)[a]	424 (94%)
No	9 (3%)[a]	19 (15%)*	28 (6%)
Total	323 (100%)	129 (100%)	452 (100%)
How frequently would you say you talk to academic scientists?			
Daily	148 (48%)*	16 (15%)[a]	164 (39%)
Weekly	110 (35%)	47 (43%)	157 (37%)
Monthly	45 (15%)[a]	40 (36%)*	85 (20%)
Yearly	6 (2%)[a]	7 (6%)*	13 (3%)
Less than once a year	1 (0%)	0 (0%)	1 (0%)
Total	310 (100%)	110 (100%)	420 (100%)
Perceptions about publications			
Working on publications for a peer reviewed journal is a good use of my workplace's budget			
Strongly disagree	19 (6%)	6 (5%)	25 (6%)
Disagree	17 (5%)	5 (4%)	22 (5%)
Neither agree nor disagree	41 (13%)	25 (20%)	66 (15%)
Agree	119 (38%)	51 (41%)	170 (39%)
Strongly agree	117 (37%)	38 (30%)	155 (35%)
Total	313 (100%)	125 (100%)	438 (100%)
Writing peer-reviewed journal articles is a waste of time for me			
Strongly disagree	205 (64%)*	66 (51%)[a]	271 (60%)
Disagree	91 (28%)[a]	53 (41%)*	144 (32%)
Neither agree nor disagree	12 (4%)	9 (7%)	21 (5%)
Agree	7 (2%)	1 (1%)	8 (2%)
Strongly agree	6 (2%)	0 (0%)	6 (1%)
Total	321 (100%)	129 (100%)	450 (100%)

* Positive association between row and column

[a] Negative association between row and column

Response categories "Don't know" and "I prefer not to answer" have been excluded

Results

Demographics, education, work, and workplace characteristics

Table 1 provides the survey demographics and respondents' education, work and, workplace characteristics. The majority of the respondents selected were male (80%), white (75%), and located outside the US (64%). The average respondents' age was 48 years (SD = 10). The average year they earned their highest degree was 1992 (SD = 11). They had worked an average of 15 years at their current institution or company (SD = 10). They

Table 3 Chi square test of association between identifying as an academic and workplace characteristics/information

Do you consider yourself to be an academic?	Yes	No	Total
	326 (72%)	129 (28%)	455 (100%)
Workplace characteristics			
Which of the following best describes the primary mission of your workplace?			
Fundamental research	226 (70%)*	45 (35%)[a]	271 (60%)
Teaching students	8 (2%)	0 (0%)	8 (2%)
Creating and implementing public policy	12 (4%)[a]	13 (10%)*	25 (6%)
Manufacturing products for sale	10 (3%)[a]	15 (12%) *	25 (6%)
Providing services for sale	16 (5%)	6 (5%)	22 (5%)
Other	50 (16%)[a]	50 (39%)*	100 (22%)
Total	322 (100%)	129 (100%)	451 (100%)
Does your workplace routinely collaborate with universities for research?			
Yes	294 (92%)	108 (86%)	402 (90%)
No	27 (8%)	18 (14%)	45 (10%)
Total	321 (100%)	126 (100%)	447 (100%)
Does your workplace expect you to publish?			
Yes	300 (94%)*	95 (76%)[a]	395 (89%)
No	20 (6%)[a]	30 (24%)*	50 (11%)
Total	320 (100%)	125 (100%)	445 (100%)
Does your workplace provide you with time and resources to publish?			
Yes	268 (85%)*	90 (73%)[a]	358 (81%)
No	49 (15%)[a]	34 (27%)*	83 (19%)
Total	317 (100%)	124 (100%)	441 (100%)
Information			
I routinely read peer-reviewed journal articles			
Strongly disagree	21 (6%)	10 (8%)	31 (7%)
Disagree	11 (3%)	5 (4%)	16 (4%)
Neither agree nor disagree	17 (5%)[a]	16 (12%)*	33 (7%)
Agree	109 (33%)	53 (41%)	162 (36%)
Strongly agree	168 (52%)*	45 (35%)[a]	213 (47%)
Total	326 (100%)	129 (100%)	455 (100%)
I often get ideas from academic articles that can be applied to my work			
Strongly disagree	12 (4%)	2 (2%)	14 (3%)
Disagree	11 (3%)[a]	12 (9%)*	23 (5%)
Neither agree nor disagree	36 (11%)[a]	26 (20%)*	62 (14%)
Agree	167 (52%)	63 (49%)	230 (51%)
Strongly agree	96 (30%)*	26 (20%)[a]	122 (27%)
Total	322 (100%)	129 (100%)	451 (100%)

* Positive association between row and column

[a] Negative association between row and column

Response categories "Don't know" and "I prefer not to answer" have been excluded

Table 4 Job and workplace characteristics themes ($n = 401$)

Code	Description	*N*	%
Topic	Respondent discussed the topic of their research or work	281	70.1
Duties	Respondent described the duties they perform at their work	273	68.1
Site	Respondent identified the type of organization or geographic location of their workplace	221	55.1
Role	Respondent explicitly listed their work role and/or title	166	41.4
Mission	Respondent mentioned their workplace's mission	125	31.2

worked on average 50 h a week (SD = 12) and devoted 21 h a week to writing and editing publications. They supervised on average 14 employees in their organization (SD = 50). There was not strong agreement over whether they would prefer a position in a college/university, but the modal response was no (41%). The largest workplace setting in this sample was national governmental organizations (51%).

Workplace collaboration culture

Tables 2, 3 and 5 (Electronic supplementary material) provide information about workplace collaboration culture and characteristics. High levels of research publishing and collaboration with universities were reported at both the individual and workplace level. The vast majority of respondents (93%) had collaborated professionally with academic scientists in the past 5 years, and reported that they talked with academic scientists on a daily (37%), weekly (37%), or monthly (19%) basis.

Most respondents were expected to publish at their workplace (87%) and were provided with time and resources to publish by their organization (78%). However, less than a third (30%) of workplaces provided extra incentives for publishing (see Table 4). Most respondents felt that working on publications was a good use of their workplace's budget (71% agreed or strongly agreed). The vast majority (90%) disagreed or strongly disagreed with the statement that writing peer-reviewed articles was a waste of time. They reported that their interest in publishing was shared by most of their co-workers (67% agreed or strongly agreed).

The majority of the respondents were content with the amount of time they spent engaging with academic scientists (63%), although roughly a third of respondents said they would like to spend more time engaging with academic scientists (32%). Most authors also stated that their organization routinely collaborated with universities for research (88%). Respondents said that collaborations with universities were viewed favorably by most of their colleagues at their workplace (85%).

Most respondents said they routinely read peer-reviewed journal articles (83% agreed or strongly agreed). They also reported that they often got ideas from these articles that could be applied to their own work (78% agreed or strongly agreed). However, there was no consensus on if they would be rewarded for figuring out how to apply an innovation to their own work. This indicates that the incentive structure for innovation is not clearly established in many workplaces. Respondents said that scientific innovation typically comes from academia through reading academic publications (37%), from personal communication with academics (22%) or from within their own organization (20%). The majority of

respondents reported that protecting proprietary information was not an important consideration for their organization when choosing to collaborate with universities (53%). However, 32.6% reported that it was a major concern for their workplace.

Motivations for collaborating with academics or universities

Table 6 (Electronic supplementary material) provides data on respondents' level of agreement on a 1-to-5 Likert scale with potential personal motivations for collaborating with academics or universities for research (Likert 1932). The respondents agreed that they could apply innovations generated by their collaborators to their work (80% agreed or strongly agreed). They also believed that the collaborative process is synergistic and helps them to generate innovations (90% agreed or strongly agreed). The majority of respondents agreed that gaining prestige in their workplace motivated them to collaborate with academics/universities (55% agreed or strongly agreed), but 27% neither agreed nor disagreed. Most respondents disagreed that receiving monetary compensation was a source of motivation (67% strongly disagreed or disagreed). They reported the opportunity to disseminate their ideas was a major motivation (75% agreed or strongly agreed). Most respondents also shared the worldview that such collaborations are broadly beneficial to society (90% agreed or strongly agreed). Many also reported that these collaborations are a part of the normal operating procedure at their workplace (79% agreed or strongly agreed).

We also asked respondents to rate their level of agreement on a Likert scale with potential workplace motivations for collaborating with academics or universities for research. The survey asked if perceptions of academics' objectivity, qualifications, and cost effectiveness shaped whether or not their workplaces chose to collaborate. There was less consensus among respondents about workplace motivations than for personal motivations. In addition, respondents free listed other motivations for collaborating with academics for research. Respondents identified 29 unique motivations. Motivations that were identified by at least five respondents are listed in Table 7 (Electronic supplementary material). Motivations also varied greatly by workplace type as shown in Table 8 (Electronic supplementary material).

Collaboration culture

Table 9 (in Electronic supplementary material) provides data on collaboration culture. Respondents reported that the most common source of funding for their collaborative research with academics came from a government source (48%) or their workplace (29%). They also reported that the research was typically evenly distributed between their workplace and the academic collaborator (55%). Some respondents felt that the bulk of the research was done by them and others in their workplace (31%) and a few said that it was done by their academic collaborators (8%). Publishing an article in a peer-reviewed journal (96%) and presentation at a conference (82%) were the methods most often used to disseminate the results of their research. Respondents most often reported that they and their coworkers (37%) were the people primarily applying their findings to real world problems. However, 28% thought that both collaborators played an equal role in this process.

Chi square results

A Chi square test of association was used to test whether there is any association between self-identification as an academic and their level of collaboration, publishing perceptions, workplace characteristics, and information sources (Tables 2, 3). Significant positive associations were found between scientists who considered themselves academics and had professional collaborations with academic scientists in the past five years, who communicated with an academic scientist daily, and whose workplace collaborated with universities for research. Scientists who considered themselves academics also strongly agreed that working on publications for a peer reviewed journal was a good utilization of their workplace's budget and not a waste of their time. This strongly points to the academic characteristics of their organizations despite their location in state and industry sectors.

Scientists who considered themselves academics also said that fundamental research was the main mission of their organization. A few respondents also mentioned that teaching students was their organization's main mission. Significant positive associations were also found between scientists who self-identified as academics and said that their workplace considered publications important and they received time and resources from their workplace to publish. A statistically significant positive association was also found between scientists who considered themselves academics and strongly agreed that they routinely read peer reviewed articles, and often got ideas from academic articles that could be applied to their work.

Job and workplace characteristics

We also asked respondents to describe in one or two sentences their job and workplace. Most respondents (85.5%) provided a response to this question. We hypothesized that these individuals would be describing more applied research and work. However, through analyzing respondents' descriptions of their work and workplace setting we found that the majority of our respondents were doing fundamental research in government research organizations and labs. This finding is consistent with their responses to the close-ended questions. These narrative responses also provide additional details about their daily work experiences and research that help to better understand their job and organization. They also highlight the disciplinary and geographic diversity of our survey's respondents. Their responses focused on five general themes: their role in the organization, the site of their work, the duties they performed, their workplace's mission, and the topic of their work and/or research (Table 4).

Respondents' responses referenced job and workplace themes that varied at an individual, work group, and/or workplace level (Fig. 1). Job roles varied at the individual level. Job site and mission varied at the workplace level, though some respondents reported working in multiple locations. Some respondents reported having individualized job duties, whereas others said their duties were consistent within their work group. The topic of their work varied at the individual, work group, and workplace levels. The variance of these categories at the individual, work group, or entire workplace level highlights different types of workplaces and levels of autonomy for researchers working in non-university settings. For example, in a university setting research topics vary greatly and are selected by each individual researcher, whereas in a government or industry the topic may be determined by and consistent across the workplace. Alternatively, it can also vary at the

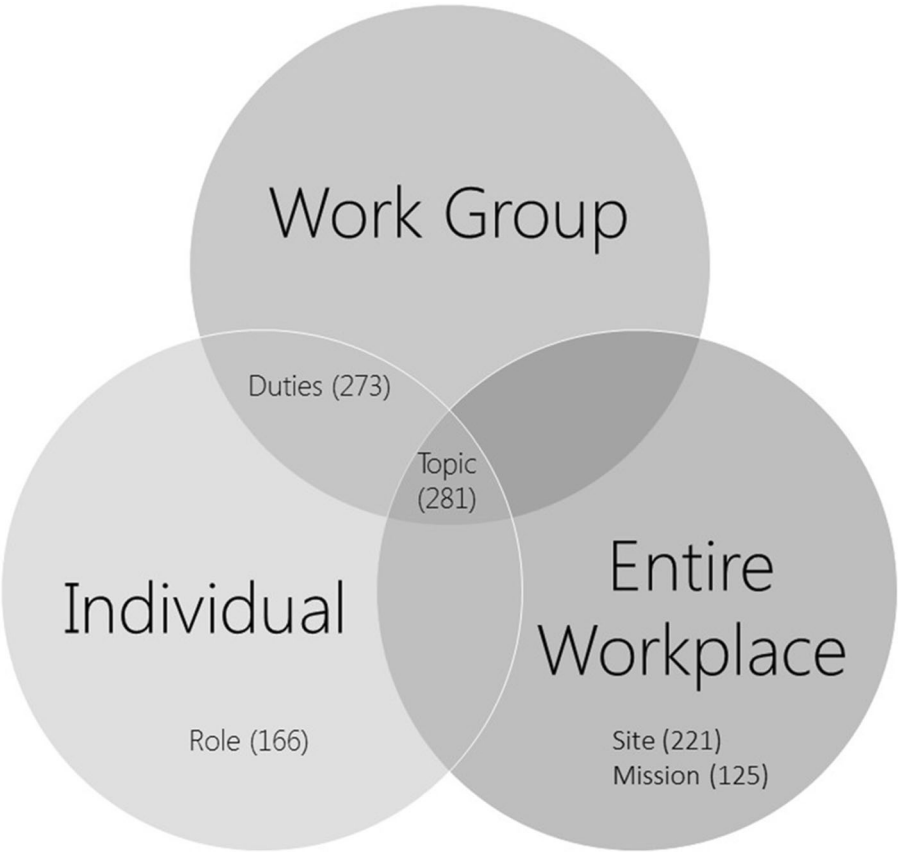

Fig. 1 Job and workplace theme variance at the individual, work group, and workplace level

work group (i.e. lab) or individual level. This variance in responses illustrates different types of workplace organization and research cultures.

Research/work topic also had the widest range of responses with most respondents describing a unique combination of topics. Respondents provided a wide range of unique ($n = 1$) topics from quantum dots to music education. This variation resembles the diversity found in academia more generally. Fundamental research and health topics were the most common responses (Table 10 in Electronic supplementary material). Some respondents were very $_{\text{specific}}$ and used discipline specific jargon to talk about their topic. This was especially common among respondents working on fundamental research topics. Others choose to be more general to speak to a broader audience. This often occurred when the topic was related to health.

Our qualitative analysis highlighted the research focused nature of our respondents' work. Most responses emphasized the research focus of respondents' jobs and workplaces. Research/work topic was the most common theme discussed by respondents (Table 10 in Electronic supplementary material). Research was also the duty most frequently reported by respondents (Table 11 in Electronic supplementary material). The modal workplace referenced was a research organization (Table 12 in Electronic supplementary material). The role most frequently identified was a researcher, followed by scientist (Table 13 in

Electronic supplementary material). Furthermore, the most respondents' reported fundamental research as their workplace mission (Table 14 in Electronic supplementary material). The following description illustrates a typical survey respondent's job and workplace characteristics:

> "I am working at an Institute for Coastal Research as a climate scientist doing general system analysis and modelling. In detail, I am analysing [analyzing] observational datasets (climate datasets, sea level data) as well as reanalysis data and also model output (GCMs and RGMs) and proxy data. As I am doing mainly statistical analyzing [analyzing], my daily work happens in front of a computer in the office. I am not doing fieldwork. I do not teach, but sometimes I give a seminar at university. And of course I always have to be up to date about current research results, so I read a lot (usually online). I publish my results in peer-reviewed journals and present them on international conferences."

The job and workplace characteristics described by the majority of respondents very closely resemble those found in university settings, with the majority of their work time devoted to research. These findings illustrate the central focus placed on academic research in many non-university workplace settings that have traditionally been classified as non-academic. These qualitative findings help to explain why the majority of respondents self-identify as academics despite working primarily in non-university settings.

Discussion

The original subject of our study was to examine the interaction between academics at universities and practitioners in other settings. We hypothesized that people working in non-university settings who collaborated and published with academics working in university settings were agents of circulating knowledge among practitioners. To examine this population, we surveyed randomly selected researchers who publish articles in WoS and work in non-university settings in this study. We were surprised to find that most (72%) of these researchers self-identified as academics regardless of their workplace setting and the majority (60%) were based in a fundamental research focused workplace. This finding falsified our underlying assumption that people who worked in non-university settings did not identify as academics and did not have a fundamental research focused workplace.

As a result, the focus of our analysis shifted to further explore these findings and test for a correlation between whether or not a respondent self-identified as an academic and their level of collaboration, publishing perceptions, workplace characteristics, and information sources. Significant positive associations were found between researchers who self-identified as academics and reported that (1) they frequently engaged in professional collaboration and communication with academic scientists, (2) their workplace had positive perceptions towards publishing, (3) their organization's primary mission is fundamental research, and (4) they relied heavily on peer-reviewed articles as both information sources and modes for transferring knowledge and innovation to other academics. These findings indicate that these researchers' workplace characteristics and perceptions encouraged collaboration and knowledge dissemination via peer-reviewed publications. Our qualitative analysis of respondents' open-ended responses revealed that most researchers surveyed conducted fundamental research in laboratories and research organizations for governmental agencies, rather than working as practitioners in more applied settings, as we had

initially hypothesized. These findings indicate that many scientists who work in research focused governmental organizations have similar duties to their peers who work at universities. It also suggests that different methods should be used to identity practitioners working in industry.

Publishing appears to be a marker of academic status. Most of the researchers surveyed reported that their workplaces expected them to regularly publish and provided them with time and resources to complete this duty. Most researchers said that they enjoyed working on publications, but few reported being provided with incentives for publishing. These findings suggest that the term academic is evolving to fit a changing research landscape and funding climate. As a result, the definition of an academic should be expanded to include these individuals.

Conclusions and suggestions for further research

Our survey revealed that the vast majority of researchers who publish consider themselves academics. Our findings have a broader impact because they quantify the evolution of academia and academic identity outside of university settings. WoS is far more academic than we had anticipated. We had initially hypothesized that many authors of peer-reviewed articles did not identify as academics or work in fundamental research settings, especially those who worked in non-university settings. However, this hypothesis was not supported by our data. The overwhelming majority of authors publishing in the WoS (77%) work at colleges or universities. Furthermore, of those who publish in WoS and work in non-university settings less than a third (28%) do not self-identify as academics. These scientists' workplace attributes parallel those found at universities with the majority working in national government organizations whose primary mission is doing fundamental research. These workplaces also promoted academic research and publication of peer-reviewed articles. These findings will impact how future studies attempt to survey researchers working in non-university settings, identify those who do not identify as academics, and learn about different types of research workplaces. This study's use of a survey with a statistically representative sample allows us to conclude that collaboration between scientists working in university and non-university settings has changed the dissemination of scientific innovation. However, we found that surveying authors of WoS peer-reviewed publications is not the best way to examine the role of the Triple Helix concept in knowledge transfer and scientific innovation. This finding can help to improve our understanding of the pathways of innovation and knowledge transfer between government, industry, and the university. It also has implications for how future studies will measure coordination and diffusion of research innovations across these sectors. The current landscape of academia requires further involvement of all researchers to conduct and publish their discoveries for the benefit of science and society.

We acknowledge that our study may be limited by its sampling of only authors of publications in non-university settings, as well as the variance between these organizations' work environments in terms of their institutional values and incentive structures. We conclude that analysis of publication data is not the best way to identify researchers working in industry. Future studies could look at patent or conference presentation data to see if a similar interaction occurs. They could also compare the motivations of authors a university setting to those in a non-university setting. Our results also show that many governments and industries hire scientists to conduct fundamental research within their

organizations. Future studies could also examine these researchers' level of collaboration with governmental or industry partners.

Acknowledgements This research was supported by a National Science Foundation grant from the Science of Science Policy program award number 0738116.

References

Abramo, G., D'Angelo, C. A., Di Costa, F., & Solazzi, M. (2009). University-industry collaboration in Italy: A bibliometric examination. *Technovation, 29,* 498–507.

Agrawal, A. (2001). University-industry knowledge transfer: Literature review and unanswered questions. *International Journal of Management Reviews, 3*(4), 285–302.

Altbach, P. G. (1996). *The international academic profession*. Princeton, NJ: Carnegie Foundation for the Advancement of Teaching.

Altbach, P. G. (1997). An international academic crisis? The American professoriate in comparative perspective. *Daedalus, 126*(4), 315–338.

Beaver, D. D., & Rosen, R. (1978). Studies in scientific collaboration 1. The professional origins of scientific co-authorship. *Scientometrics, 1,* 65–84.

Belkhodja, O., & Landry, R. (2007). The Triple-Helix collaboration: Why do researchers collaborate with industry and the government? What are the factors that influence the perceived barriers? *Scientometrics, 70,* 301.

Bhattacharya, S., & Meyer, M. (2003). Large firms and the science-technology interface - patents, patent citations, and scientific output of multinational corporations in thin films. *Scientometrics, 58,* 265–279.

Börner, K., Dall'Asta, L., Ke, W., & Vespignani, A. (2005). Studying the emerging global brain: Analyzing and visualizing the impact of co-authorship teams. *Complexity, Special Issue on Understanding Complex Systems, 10,* 57–67.

Butcher, J., & Jeffrey, P. (2005). The use of bibliometric indicators to explore industry- academia collaboration trends over time in the field of membrane use for water treatment. *Technovation, 25,* 1273.

Butler, L., & Visser, M. S. (2006). Extending citation analysis to non-source items. *Scientometrics, 66,* 327.

Clark, Burton R. (1997). Small worlds, different worlds: The uniquenesses and troubles of American academic professions. *Daedalus, 126*(4), 21–42.

de Solla Price, D. (1965). Is technology historically independent of science? A study in statistical historiography. *Technology and Culture, 6,* 553–568.

Etzkowitz, H., & Leydesdorff, L. (1995). The Triple Helix–University-industry-government relations: A laboratory for knowledge based economic development. *EASST review, 14*(1), 14–19.

Fan, W., & Yan, Z. (2010). Factors affecting response rates of the web survey: A systematic review. *Computers in Human Behavior, 26*(2), 132–139.

Frenken, K., Holzl, W., & de Vor, F. (2005). The citation impact of research collaborations: The case of European biotechnology and applied microbiology (1988–2002). *Journal of Engineering and Technology Management, 22,* 9–30.

Geuna, A., & Muscio, A. (2008). The governance of University knowledge transfer. *Science and Technology Policy Research, 173,* 1–29.

Glaser, B. G., & Strauss, A. L. (2009). *The discovery of grounded theory: Strategies for qualitative research.* Transaction publishers.

Godin, B. (1996). Research and the practice of publication in industries. *Research Policy, 25,* 587–606.

Godin, B., Barker, R. S., & Landry, R. (1995). Besides academic publications - which sectors compete, or are there competitors. *Scientometrics, 33,* 3–12.

Henkel, M. (2005). Academic identity and autonomy in a changing policy environment. *Higher Education, 49*(1–2), 155–176.

Hicks, D. (1995). Tacit competencies and corporate management of the public/private character of knowledge. *Industrial and Corporate Change, 4,* 401–424.

Hopkins, A. L., Jawitz, J. W., McCarty, C., Goldman, A., & Basu, N. B. (2013). Disparities in publication patterns by gender, race and ethnicity based on a survey of a random sample of authors. *Scientometrics*, *96*(2), 515–534.

IBM Corp. (2013). IBM SPSS Statistics for Windows, Version 22.0. Armonk, NY: IBM Corp.

Katz, J., & Martin, B. (1997). What is research collaboration? *Research Policy, 26,* 1–18.

Kogan, M. (2000). Higher education communities and academic identity. *Higher Education Quarterly, 54*(3), 207–216.
Leydesdorff, L., & Meyer, M. (2007). The scientometrics of a Triple Helix of university- industry-government relations (Introduction to the topical issue). *Scientometrics, 70*(2), 207–222.
Likert, R. (1932). A technique for the measurement of attitudes. *Archives of Psychology, 140,* 1–55.
Lundberg, J., Tomson, G., Lundkvist, I., Skar, J., & Brommels, M. (2006). Collaboration uncovered: Exploring the adequacy of measuring university-industry collaboration through co-authorship and funding. *Scientometrics, 69,* 575–589.
MAXQDA, software for qualitative data analysis. (1989–2016). VERBI Software—Consult—Sozialforschung GmbH, Berlin, Germany.
McCarty, C., & Jawitz, J. (2013). Attitudes about publishing and normal science advancement. *Journal of Informetrics, 7*(4), 850–858.
McCarty, C., Jawitz, J., Hopkins, A., & Goldman, A. (2013). Predicting author h-index using characteristics of the co-author network. *Scientometrics, 96*(2), 467–483.
McMillan, G., & Hamilton, R. (2000). Corporations need to publish—or perish. *Research- Technology Management, 43,* 8–10.
Merton, R. (1973). *The sociology of science*. Chicago, IL: University of Chicago Press.
Nelson, R. (1990). Capitalism as an engine of progress. *Research Policy, 19,* 193–214.
OED. (2016). Academic, n. and adj. Oxford University Press. Web. 3 January 2017.
Pavitt, K., & Walker, W. (1976). Government policies towards industrial innovation: a review. *Research Policy, 5*(1), 11–97.
R Development Core Team (2008). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. ISBN 3-900051-07-0, http://www.R-project.org.
Ryan, G. W., & Bernard, H. R. (2003). Techniques to identify themes. *Field methods*, *15*(1), 85–109.
Schimank, U., & Winnes, M. (2000). Beyond Humboldt? The relationship between teaching and research in European university systems. *Science and public policy, 27*(6), 397–408.
Zhao, D. (2005). Challenges of scholarly publications on the web to the evaluation of science–A comparison of author visibility on the Web and in print journals. *Information Processing and Management, 41,* 1403.