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Article

Does public outreach impede research performance? Exploring the 'researcher's dilemma' in a sustainability research center

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Abstract

Researchers and universities are increasingly urged to communicate their findings to the general public. Despite the broad consensus about the necessity of this task, researchers are still reluctant to engage in public outreach activities. One major reason is that while being somewhat time consuming, engagement in public outreach is not adequately reflected in the metrics that are relevant for career advancement. The study at hand examines to what extent this dilemma is empirically justified. A series of statistical analyses are carried out on the basis of data from a sustainability science research center in Switzerland. The study comes to the conclusion that research performance is overall positively associated to engagement in public outreach activities. This insight has implications for the academic incentive and evaluation system.

Key words: public outreach; research center; sustainability science; research performance

1. Introduction

The old dream of unconditional support for basic research is long over. Governmental budget cuts and global competition for research funds have maneuvered the classic 'ivory tower' university system into rough waters. Paradigmatic shifts labeled as diverse as mode 2 knowledge production (Gibbons et al. 1994; Nowotny et al. 2003), postacademic science (Ziman 2002), or the triple-helix of university–government–industry relations (Etzkowitz and Leydesdorff 2000) all highlight the increased expectation toward academic research to yield growth-inducing innovation and applied knowledge of societal relevance (D'Este et al. 2018; Hessels et al. 2009). Furthermore, mounting demands for public accountability have led to new policies in the allocation of funds, including the increased focus on prospective 'dissemination strategies' in grant proposals (Holbrook 2010), or even the earmarking of fixed percentages for reaching out to the tax-paying public (Martin 2011).

Not all researchers are pleased about this development because it steers them and their groups into a fundamental dilemma situation: on the one hand, the academic 'publish or perish' system pressurizes them to produce as many scientific publications as possible in the limited time available. At the same time they are expected to dedicate a share of their capacities to so-called 'public outreach activities', the outputs of which are barely or at least not adequately accounted for in the relevant metrics and career promotion. In other words, there is an evident mismatch between the academic's mandate and the academic reward system.

The jury is still out on how engagement in public outreach activities actually affects the research performance of individuals and their groups. The aim of this study is to shed some light into this research policy discourse. A few studies have already addressed this question empirically. The study at hand differs from previous studies in that it deals with the issue in the context of a research center in the field of sustainability science. This comes with at least two advantages: first, because a research center is an organizationally and temporally closed system in which the respective outputs—that is, scientific outputs and outputs from public outreach activities—can be clearly assigned to one another. And second, because sustainability science, as a very solution-oriented field of study, is an exemplary field for the dilemma described above.

The remainder of this article is structured as follows. Section 2 is a literature review. It is followed by the description of the case. In Section 4, data and methods are presented. Section 5 reports the results. The last section discusses the findings and draws conclusions for further research while consolidating the implications for research policy.

2.Public outreach and the researcher's dilemma

2.1 What are public outreach activities?

The role and responsibility of academia in finding solutions for the grand societal challenges of our time—like climate change, energy supply, urbanization, or sustainable mobility—is widely

acknowledged (SDSN 2017). The biggest shortcoming in this context, however, remains the ineffective linkage between knowledge and action. Originally assumed that research findings would simply 'trickle down' to where they would be needed, this somewhat unrealistic notion was soon replaced by the so-called 'transfer and translate model'. According to this model, 'research is characterized as a product that needs to be taken up by the relevant user communities. Activities to facilitate this transfer often include efforts to translate technical, jargon-laden science into terms that can be understood by the layperson' (Van Kerkhoff and Lebel 2006: 450).

Various terms have been utilized to name these efforts, including 'public outreach' (Andrews et al. 2005), 'science outreach' (Johnson et al. 2014), 'science communication' (Burns et al. 2003), 'popularization' (Myers 2003), 'knowledge dissemination' (Green et al. 2009), or 'public engagement' (Watermeyer 2015). Just as there is no real consensus on the terminology, there is also no common understanding on where 'research' ends and where 'public outreach' begins. The activities rather lie on a continuum of different genres 'from arcane technical laboratory discussions on the one end, via conference presentations, and published literature, to lectures and writings for wider audiences outside the peer group on the other end' (Bauer and Jensen 2011).

Rowe and Frewer (2005) suggested a straightforward typology, differentiating three types of public outreach activities: by 'public communication' they mean the dissemination of information by researchers to the public. This type is characterized by a one-way information flow and no direct involvement of the recipients. In the type 'public consultation', as the name suggests, researchers actively seek and obtain information and feedback from the public. In the third type, 'public participation', information is exchanged between researchers and the public through a bidirectional and dialog-based manner (Rowe and Frewer 2005: 255). What all three types have in common is the aim to create societal added value by processing and communicating research findings. The types differ, as described, with regard to the direction of knowledge flow on the one hand, but also in terms of the effort needed. The largest effort is associated with public participation, which is underpinned by a complex transdisciplinary process (Lang et al. 2012). In turn, the smallest effort is attached to public communication, because researchers design the output themselves without involving representatives of sectors beyond academia (Jensen et al. 2008). Therefore, it is also the type that is most frequently applied in practice, especially when public outreach activities are carried out as pro forma activities, as is succinctly described by Bauer and Jensen (2011): 'the intrinsic motivation of engage the public because it is fun or part of a personal ethos is crowded-out by institutional incentives and defined duties that are set by institutional commitments'. The study at hands follows the typology of Rowe and Frewer (2005) and defines public outreach activities in the way they understand public communication, that is, a one-way dissemination of knowledge for the benefit of society.

2.2 The 'researcher's dilemma': which factors play a role?

The researcher's dilemma is based on the consideration that researchers have to decide whether to spend their time exclusively on classical academic activities to produce scientific publications, or to additionally engage in public outreach activities. While the former is rewarded by the current academic system, as evident in rankings or recruitment processes, for example, researchers barely receive recognition for the latter, if any at all. This 'persistent ambiguity' (Olmos-Peñuela et al. 2015) has profound negative implications on the motivation and ultimately on the quality of the activities.

Several studies have focused on identifying which factors play a role in whether or not researchers engage in public outreach activities (Bentley and Kyvik 2011; Kuehne and Olden 2015; Llopis et al. 2018). Some researchers, according to one study, have an intrinsic motivation to contribute to society (Greenwood and Riordan 2001). Others feel a moral obligation toward the tax-paying public (Martinez-Conde 2016; Peters 2013). For some, the commitment even goes hand in hand with an increased feeling of their own reputation (Liang et al. 2014). Again, others enjoy conveying knowledge to children through play, also because they believe these activities can improve their teaching and communication skills (Andrews et al. 2005).

It has also been found that academic age plays a role, with public outreach increasing with experience (Bauer and Jensen 2011; Poliakoff and Webb 2007). Academic identity in terms of past experiences was also identified as a possible determinant (Olmos-Peñuela et al. 2015), or the disciplinary background, with the distinction that public outreach is more frequently conducted in 'soft sciences' (i.e. humanities and social sciences) rather than by representatives of 'hard sciences', including natural sciences or medicine (Winter 2004). Finally, some studies also show differences in nationality (Miller 1998), gender (Johnson et al. 2014), and organizational contexts (Johnson et al. 2014; Thune et al. 2016).

Factors that have been found to hinder researchers from engaging in public outreach activities include lack of time (Andrews et al. 2005; Gascoigne and Metcalfe 1997; Poliakoff and Webb 2007), doubts about own communication skills (Besley and Tanner 2011), lack of interest (Checkoway 2001), lack of information on public outreach opportunities, and lack of support for conducting public outreach activities (Andrews et al. 2005; Kim and Fortner 2008). Most consistently, the lack of the 'right incentives' and 'appreciation' by supervisors, colleagues, departments, and the academic system in general were identified as obstacles (Amey et al. 2002; Andrews et al. 2005; Jensen et al. 2008; Martín-Sempere et al. 2008; Wise et al. 2002). In other words, public outreach activities are commonly considered as 'incompatible with a successful academic career' (Martinez-Conde 2016), even as professionally risky (Ecklund et al. 2012).

2.3 How do public outreach activities and research performance relate?

As the results of numerous studies have shown, there is a fundamental tension between engaging in public outreach activities and the rewards researchers presumably receive for them. Rumor holds that public outreach activities will come at the expense of research performance. This understanding is reinforced by a few yet often cited surveys conducted by the Royal Society (2006) and the Wellcome Trust (2000), which reported their respondents to have said 'public engagement was done by those who were "not good enough" for an academic career' (Royal Society 2006). Another prominent example for this belief is the so-called 'Sagan effect'. Named after the astrophysicist Carl Sagan, it suggests that researchers with too much public visibility are not taken seriously by their peers, but are rather seen as popular scientists with a lack of rigor, which in turn weakens their reputation in expert communities and can thus negatively influence their careers. Paradoxically, over the course of his career Sagan

averaged one journal article per month (Jensen et al. 2008), so the question necessarily arises whether the researcher's dilemma is really legitimate, or whether the opportunity costs are just an 'urban legend'?

The few larger-scale empirical studies that have been conducted on this matter come to mixed results. Either they find that the engagement in public outreach activities has a positive effect on researchers performance (Bentley and Kyvik 2011; Jensen et al. 2008; van der Weijden et al. 2012; Van Looy et al. 2011), or that they are independent, neither impeding nor improving the other (Gulbrandsen and Smeby 2005; Mostert et al. 2010). The assumption that public outreach is per se bad for research performance has, to the best of the author's knowledge, no quantitative empirical evidence.

2.4 Testing the relationship in the context of a research center

The study at hand aims to take up this discussion and provide empirical evidence that differs from previous ones in that it is assessed in the context of a research center, which is understood here as an 'entity within a university that exists chiefly to serve a research mission, is set apart from the departmental organization, and includes researchers from more than one department' (Bozeman and Boardman 2003: 17).

There are at least two advantages in studying the phenomenon in the context of a research center: first, most of the previous studies have taken into account all public outreach activities and scientific publications of researchers or their groups without the respective outputs necessarily showing any immediate association in terms of content. The research center, in contrast, pursuing a concise mission, is a temporally-closed system in which public outreach activities can be clearly assigned to corresponding scientific publications. Second, previous studies have distinguished researchers on the basis of their disciplinary backgrounds. Although it certainly makes sense to consider the different traditions of the disciplines, the context of the research center allows focusing on the commonalities of researchers, namely the field of research they are engaged in. This enables a comparative assessment across researchers and their groups.

The specific case at hand concerns a research center in the field of sustainability science, a field 'focused on practical application of theories, tools and methodologies from different disciplines and bringing together scientists and stakeholders to define important research questions and objectives in dealing with sustainability challenges' (Shahadu 2016). In contrast to highly specialized basic research, the inter- and transdisciplinary character of sustainability science makes it a prime example for the dilemma described above (Kassab et al. 2018). Before exploring the relationship empirically, the two following sections describe the case under scrutiny, the data, and the methods applied.

3. Case description: the Competence Center Environment and Sustainability of the ETH Domain[1]

The ETH Domain is a union of six research institutions in Switzerland and comprises two Federal Institutes of Technology in Zurich (ETH Zurich) and Lausanne (EPFL), as well as the four research institutes: the Paul Scherrer Institute (PSI), the Swiss Federal Institute for Forest, Snow and Landscape Research (WSL), the Swiss Federal Laboratories for Materials Science and Technology (Empa), and the Swiss Federal Institute of Aquatic Science and Technology (Eawag). Directly supervised by the Swiss Federal Council and the Parliament, the ETH Board is responsible for the strategic management of the ETH Domain and undertakes supervision of its institutions. In 2006, the ETH Board established four inter- and transdisciplinary research centers and provided funds for an operation of ten years (two phases: 2006–2010 and 2011–2016). This study looks at one of these four centers, the Competence Center Environment and Sustainability (CCES), which engaged more than 800 people and operated between 2006 and 2016 to facilitate inter- and transdisciplinary research, education, and public outreach within and between the institutions that constitute the ETH Domain. According to its business plan (CCES 2005), CCES was established with the mission to 'identify the relevant questions and the appropriate answers to foster the sustainable development of a future society while minimizing the impact on the environment' (CCES 2005). To comprehensively achieve this mission, CCES operated in three areas of activity: research, education, and public outreach. Activities at CCES were clustered in eighteen projects along five thematic areas of environment and sustainability science: (1) Climate and Environmental Change, (2) Sustainable Land Use, (3) Food, Environment, and Health, (4) Natural Resources, and (5) Natural Hazards and Risks. Some exemplary projects included *OPTIWARES*, in which researchers worked on optimizing the use of wood as a renewable energy source, or the *GEOTHERM* project, which investigated the sustainable use of enhanced geothermal systems, or the *RECORD* project, which studied the ecological, hydrological, and social dynamics in the context of river restoration.

After the completion of the first phase (2006–2010), the eighteen projects went through a rigorous review and eight of them were selected for the second phase (2011–2016). Since some of the team's constellations changed remarkably between the two phases, projects of the second phase are not regarded as follow-up projects of the first phase but rather as new projects, adding up to twenty-six projects overall.

4. Data and methods

4.1 Archival data: research performance and public outreach activities

As part of the administrative routine at the research center, the principle investigators of the twenty-six projects compiled detailed reports on an annual basis. This archival data in the form of ninety-nine annual project reports, kindly provided by the CCES management, constituted the main data source of this study. The reports disclose a broad spectrum of information related to the research center activities. For the purpose of this study, all relevant data regarding the (1) research performance and (2) the public outreach activities were retrieved on the project level (Mostert et al. 2010). With ninety-nine, the number of observations (see Table 1) is equivalent to the number of annual reports.

As to the research performance, participants of CCES published $N = 496$ peer-reviewed journal articles. The corresponding bibliometric data were retrieved from the *Clarivate Analytics Web of Science* and attributed to one of the research center's twenty-six projects. For each of the peer-reviewed journal articles, the total number of citations was retrieved and cumulated on the project level.

The public outreach activities were documented in the annual project reports on the basis of a sixfold reporting scheme, as

Table 2. Descriptive statistics of key variables.

Variable	Variable name	Number of observations (annual reports)	Mean	SD	Min	Max
Set 1: Research performance						
Number of peer-reviewed journal articles	*no_pub*	99	4.78	5.48	0	24
Total number of citations	*total_cit*	99	133.08	236.02	0	1294
Prior research performance	*prepot*	99	4.76	3.18	1.98	17.26
Set 2: POA						
Type 1: Publications for stakeholders outside the scientific community	*POA_publications*	99	0.73	1.58	0	9
Type 2: Press interviews	*POA_interviews*	99	2.13	4.79	0	30
Type 3: Courses, seminars, and workshops for stakeholders outside the scientific community	*POA_courses*	99	0.96	2.41	0	17
Type 4: Public information events for local or regional authorities or residents	*POA_events*	99	0.53	1.29	0	9
Type 5: Events, courses, or other activities at schools	*POA_schools*	99	0.35	1.00	0	6
Type 6: Other events	*POA_other*	99	0.19	0.74	0	6
Set 3: Project-related variables						
Project team size	*groupsize*	99	39.64	13.84	16	78
Accumulated FTE of leadership team	*fte_leadership*	99	1.08	0.56	0.2	2.7
Number of female team members	*female_number*	99	9.73	4.38	3	20
Number of Master and Doctoral students	*phdmas_number*	99	9.92	5.07	3	24
Relative share of third-party contributions	*third_party_share*	99	0.52	0.60	0	3.84

POA, public outreach activities.

Table 1. Six types of POA.

	Type	Abbreviation	Instances
1	Publications for stakeholders outside the scientific community (e.g. public administration)	*POA_publications*	72
2	Press interviews (e.g. newspapers, radio/TV broadcasts)	*POA_interviews*	211
3	Courses, seminars and workshops for stakeholders outside the scientific community	*POA_courses*	95
4	Public information events for local or regional authorities or residents	*POA_events*	52
5	Events, courses, or other activities at schools	*POA_schools*	35
6	Other events	*POA_other*	19
	Total		484

POA, public outreach activities.

indicated in Table 2. Patents, a seventh category, were not considered in the data collection process, because of their marginal occurrence (less than one per year in total) over the course of the research center's activity. In sum and over the twenty-six projects, the public outreach activities at CCES added up to $N = 484$.

4.2 Variables

The archival data was coded for the purpose of this study and can be classified into three sets (see Table 1):

The first set consists of variables that are related to research performance. First is the variable 'number of peer-reviewed journal articles' (*no_pub*), which represents the cumulative number of respective publications per year and per project. The variable 'total number of citations' (*total_cit*) is a bibliometric measure of the citation frequency, also cumulated per year and per project. The variable 'prior research performance' (*prepot*) is a measure of the average research performance of the team members before their participation in the research center. In creating this variable, the number of peer-reviewed journal articles of all participants was taken into account, meaning their entire publication history before they participated in the research center. For the time before the research center, the project teams were virtually assembled. Since the citation frequency has a decisive informative value about research performance over time, the indicator was calculated from the cumulative number of *total_cit* divided by the number of publications (*no_pub*) divided by the number of leading researchers (one principle investigator and the leaders of the subunits of the projects). For example, one of the projects had a leadership team consisting of seven researchers. Their entire publication output prior to participating in the research center (first publication until and including 2006) amounted to 276 publications. Until the year before their research center participation (which in this case started in 2007), those publications had accumulated a total of 14,993 citations. The 'prior research performance' (*prepot*) variable is thus: $14{,}993/276/7 = 7.76$. In sum, for each of the twenty-six projects there is a value that describes the research performance before participation in the research center.

The second set of variables is the public outreach activities. These were coded according to their frequency, per year and per project, using the typology from the annual project reports (Table 2).

The third set is variables related to the respective projects. For each project in each year there is a variable for the 'project team size' (*groupsize*), which represents the headcount number of all

participants of the project, professors, senior researchers, Master and Doctoral students, project engineers, technicians, and laboratory staff. According to a study by van der Weijden et al. (2012), group size plays a decisive role in that 'there is a trade-off between societal orientation and trying to create a large research group'. Since not all participants are involved in research centers with identical workloads (Kassab et al., under review), there is another variable capturing 'accumulated FTE of leadership team' (*fte_leadership*), including the principal investigator and the leaders of the subunits of the projects. For each year there is also a variable for 'number of female team members' (*female_number*) indicating the absolute number of women for each project, since Johnson et al. (2014) found there to be gender-specific rationales for the commitment in public outreach activities. As various studies have identified a correlation between the engagement in public outreach activities and the academic experience of researchers (Bauer and Jensen 2011; Jensen et al. 2008; Olmos-Peñuela et al. 2015), there is a variable for the absolute 'number of Master and Doctoral students' (*phdmas_number*) in the respective project per year. Finally, there is a variable of financial nature. CCES activities were financed in a threefold funding scheme, consisting of (1) CCES contributions, (2) in-kind contributions from the participating institutions, and (3) third-party contributions from private sector or public administration. While the former two financial sources come from within the academic realm, the latter represents the interaction with the 'outside' world (Spaapen and Van Drooge 2011). For every project, the 'relative share of third-party contributions' of the overall budget was computed on an annual basis (*third_party_share*).

4.3 Methods

The analysis consists of three stages, starting with a graphical description of the data to identify patterns for the relationship between research performance and public outreach activities. This first step allows an intuitive comparative assessment of the six types of public outreach activities and the number of scientific publications at the level of the twenty-six projects of the research center.

Second, a Spearman's correlation is calculated to assess the relationship between research performance, the public outreach activities, and the other relevant variables. Spearman's correlation is preferred to Pearson's correlation because the variables are not normally distributed and because it is not as sensitive to potential outliers.

Third, a series of multiple regression analyses are run to examine the strength and statistical significance of the relationship between research performance and the six different types of public outreach activities. Since the dataset contains observations for twenty-six projects with an operative of three to five years (yielding ninety-nine data rows), the models must be specified to account for within-group (or within-project) correlation (Liang and Zeger 1986). Therefore, the analyses are run using cross-sectional time series generalized estimating equation (GEE) models with robust standard errors 'clustering' on individual observations (using the 'xtgee' command in STATA 14). GEE models estimate population-averaged treatment effects (instead of subject-specific treatment effects) and account for within-group correlations among responses over time and allow for time-varying covariates (Karimli et al. 2015; Zinn et al. 2007). The unique project identifier (*project_id*) is specified as panel variable. In both stages two and three, research performance is operationalized by two different dependent variables. On the one hand, by the number of publications (*no_pub*), and on the other, by the citation frequency (*total_cit*). For each public outreach activity, a separate model is calculated for each of the dependent variables, including six control variables each (see Tables 4 and 5).

5. Results

5.1 Stage 1: different strategies and patterns for public outreach

Figure 1 illustrates the twenty-six projects of the research center along the horizontal axis. For each project, the public outreach activities are displayed stacked as bars. The bars are sorted from left to right by the number of publications in each project (large dot). The values are cumulated over the entire duration of the respective project and weighted according to the average size of the project team (publications per capita). The small dots show the relative share of third-party funds that the project has raised over its duration as a proportion of the overall budget.

Based on this initial analysis, three patterns can be identified: First, there were projects in the research center that had a higher per capita research performance (number of publications) than public outreach activities (eleven projects). Second, in exactly the opposite direction, there were projects in the research center that carried out more public outreach activities per capita than producing scientific publications (eleven projects). And third, there were projects in which both types of output roughly balanced each other out (four projects).

In other words, on the basis of this analysis, there is no conclusive indication of how research performance and public outreach activities are related. Rather, the composition of the bars indicates that the individual projects differed greatly in terms of their public outreach strategy. This not only underlines the thematic diversity of the projects, but also shows their different management approaches, existing experiences in the team, and also which projects have generated results to potentially spark public interest, which is particularly evident when looking at the number of press interviews (Type 2). No obvious pattern can be inferred in terms of the small dots that mark the share of third-party funds of the overall budget.

5.2 Stage 2: Spearman's correlation

As Table 3 indicates, there are statistically significant and moderately positive correlations between four out of six types of public outreach activities and the number of publications (*no_pub*). No statistically significant correlation exists between the number of publications and press interviews (Type 2) and events, courses, or other activities at schools (Type 5). As to the total citations, there is evidence suggesting positive correlation between all types of public outreach activities but the press interviews (Type 2). Overall, some types of public outreach activities seem to be more closely related to scientific publishing activities than others, with the press articles (Type 2) showing no statistically significant correlation in either case.

5.3 Stage 3: multiple regression analyses

5.3.1 Number of publications as dependent variable

Table 4 displays the results of six multiple regression analyses each using a cross-sectional time series GEE model to examine the effect of individual types of public outreach activities on the number of publications, controlling for various project-specific characteristics as introduced above. The results suggest a positive and statistically significant relationship between the number of publications and five

Table 3. Correlation between public outreach activities and research performance indicators.

			Spearman's ρ		N
		Variable name	Number of publications (*no_pub*)	Total citations (*total_cit*)	Annual project reports
POA	Type 1	*POA_publications*	0.31*	0.31*	99
	Type 2	*POA_interviews*	0.14	0.28	99
	Type 3	*POA_courses*	0.30*	0.38*	99
	Type 4	*POA_events*	0.21*	0.23*	99
	Type 5	*POA_schools*	0.15	0.21*	99
	Type 6	*POA_other*	0.32*	0.30*	99
POA (6-item scale, Cronbach's alpha = 0.62)		*POA_scale*	0.34*	0.45*	99
Control variables		*groupsize*	0.19	0.29*	99
		female_number	0.20*	0.25*	99
		phdmas_number	0.17	0.26*	99
		fte_leadership	0.24*	0.24*	99
		prepot	−0.11	−0.03	99
		third_party_share	0.05	0.18	99

POA, public outreach activities. Significance level: *P < 0.05.

Table 4. Multiple regression analyses with the number of publications as dependent variable.

Variables	(1) *no_pub*	(2) *no_pub*	(3) *no_pub*	(4) *no_pub*	(5) *no_pub*	(6) *no_pub*
POA_publications	0.136***					
	(0.0223)					
POA_interviews		0.0453***				
		(0.00673)				
POA_courses			0.0483***			
			(0.0169)			
POA_events				0.131***		
				(0.0246)		
POA_schools					0.0176	
					(0.0440)	
POA_other						0.161***
						(0.0366)
groupsize	−0.0199***	−0.0148**	−0.0119*	−0.0150**	−0.0148**	−0.0150**
	(0.00726)	(0.00700)	(0.00709)	(0.00730)	(0.00707)	(0.00711)
female_number	0.0565***	0.0350**	0.0453***	0.0380***	0.0510***	0.0495***
	(0.0141)	(0.0140)	(0.0139)	(0.0146)	(0.0138)	(0.0140)
phdmas_number	0.0654***	0.0584***	0.0424***	0.0519***	0.0509***	0.0523***
	(0.0164)	(0.0161)	(0.0163)	(0.0161)	(0.0160)	(0.0159)
fte_leadership	0.295***	0.271***	0.337***	0.278**	0.366***	0.340***
	(0.105)	(0.105)	(0.106)	(0.109)	(0.104)	(0.106)
prepot	0.0452**	0.0310	0.0419*	0.0423*	0.0367*	0.0372*
	(0.0228)	(0.0233)	(0.0221)	(0.0223)	(0.0222)	(0.0224)
third_party_share	−0.217***	−0.183**	−0.232***	−0.232***	−0.226***	−0.202**
	(0.0809)	(0.0784)	(0.0806)	(0.0808)	(0.0815)	(0.0812)
Constant	0.548**	0.708***	0.618**	0.759***	0.623**	0.614**
	(0.262)	(0.266)	(0.256)	(0.260)	(0.254)	(0.255)
Observations	99	99	99	99	99	99
Number of groups	26	26	26	26	26	26
Observations per group						
Min	3	3	3	3	3	3
Average	3.8	3.8	3.8	3.8	3.8	3.8
Max	5	5	5	5	5	5
Wald χ^2 (7)	89.77	102.52	66.40	85.55	59.29	79.20
Prob > χ^2	0.000	0.000	0.000	0.000	0.000	0.000

Standard errors in parentheses. Significance levels: ***P < 0.01, **P < 0.05, *P < 0.1.

Table 5. Multiple regression analyses with the total citations as dependent variable.

Variables	(1) *total_cit*	(2) *total_cit*	(3) *total_cit*	(4) *total_cit*	(5) *total_cit*	(6) *total_cit*
POA_publications	0.129***					
	(0.00510)					
POA_interviews		0.0594***				
		(0.00114)				
POA_courses			0.103***			
			(0.00272)			
POA_events				0.126***		
				(0.00467)		
POA_schools					−0.106***	
					(0.00986)	
POA_other						0.160***
						(0.00674)
groupsize	−0.00641***	−0.00452***	0.00215**	−0.00512***	−0.00130	−0.00587***
	(0.00116)	(0.00109)	(0.00108)	(0.00122)	(0.00121)	(0.00115)
female_number	0.135***	0.111***	0.129***	0.115***	0.129***	0.127***
	(0.00223)	(0.00213)	(0.00204)	(0.00235)	(0.00233)	(0.00220)
phdmas_number	0.0423***	0.0562***	0.0143***	0.0427***	0.0343***	0.0402***
	(0.00273)	(0.00268)	(0.00263)	(0.00278)	(0.00279)	(0.00268)
fte_leadership	0.559***	0.474***	0.563***	0.507***	0.575***	0.578***
	(0.0160)	(0.0151)	(0.0153)	(0.0169)	(0.0165)	(0.0159)
prepot	0.117***	0.0972***	0.121***	0.114***	0.104***	0.107***
	(0.00348)	(0.00345)	(0.00320)	(0.00350)	(0.00358)	(0.00337)
third_party_share	0.0157	0.0469***	0.0318***	−0.0279**	−0.0743***	0.0263**
	(0.0130)	(0.0129)	(0.0122)	(0.0137)	(0.0137)	(0.0129)
Constant	1.852***	1.984***	1.793***	2.128***	2.023***	2.018***
	(0.0463)	(0.0455)	(0.0434)	(0.0472)	(0.0480)	(0.0445)
Observations	99	99	99	99	99	99
Number of groups	26	26	26	26	26	26
Observations per group						
Min	3	3	3	3	3	3
Average	3.8	3.8	3.8	3.8	3.8	3.8
Max	5	5	5	5	5	5
Wald χ^2 (7)	7,455.59	10,197.47	9,441.46	7,215.96	6,295.28	7,862.83
Prob > χ^2	0.000	0.000	0.000	0.000	0.000	0.000

Standard errors in parentheses.
Significance levels: ***P < 0.01, **P < 0.05, *P < 0.1.

types of public outreach activities, with the exception of events, courses, or other activities at schools (Type 5). For example, for every additional publication for stakeholders outside the scientific community (Type 1), a 0.136 unit increase in the number of publications is predicted, holding all other variables constant. Much smaller are the coefficients in the case of press interviews (Type 2; 0.045), or in the case of courses, seminars, and workshops for stakeholders outside the scientific community (Type 3; 0.048). Across all six models, the coefficients for the project team size (*groupsize*) and the relative share of the third-party contributions (*third_party_share*) show negative signs statistically different from zero. The sizes of the coefficients for the former, however, are very small (e.g. −0.002 in Model 1), while the ones of the latter are quite noticeable (−0.232 in Model 3). Almost all other coefficients of the covariates show positive and statistically significant correlations with the dependent variable, including the number of female team members (*female_number*), the number of Master and Doctoral students (*phdmas_number*), and the accumulated full-time equivalents (FTE) of the project leadership (*fte_leadership*). Overall, the results seem to lend support to the notion that public outreach activities are positively correlated to research performance in terms of the number of publications. As the STATA command used does not provide the *R*-squared values, the regression analyses were additionally run without the clustering 'xtgee' command (not reported in Table). Over the six models, the results indicate the predictors to explain between 14 and 20 per cent of the variance.

5.3.2 Total citations as dependent variable

Table 5 displays the results of six multiple regression analyses using the same statistical procedure and specifications as above to examine the effect of the public outreach activities on the total citations. Somewhat similar to what was found for the number of publications (Table 4), the results suggest a positive and statistically significant relationship as well. For every additional course, seminar, and workshop for stakeholders outside the scientific community (Type 3), a 0.103 unit increase in the number of total citations is predicted, holding all other variables constant. Events, courses, or other activities at schools (Type 5) again stand out as an exception, this time even showing a negative sign. Like with the number of publications, the coefficients for the project team size (*groupsize*) show negative signs and statistical significance in five out of six cases. Unlike above, the relative share of the third-party contributions (*third_party_share*) does not show negative signs throughout, but only for

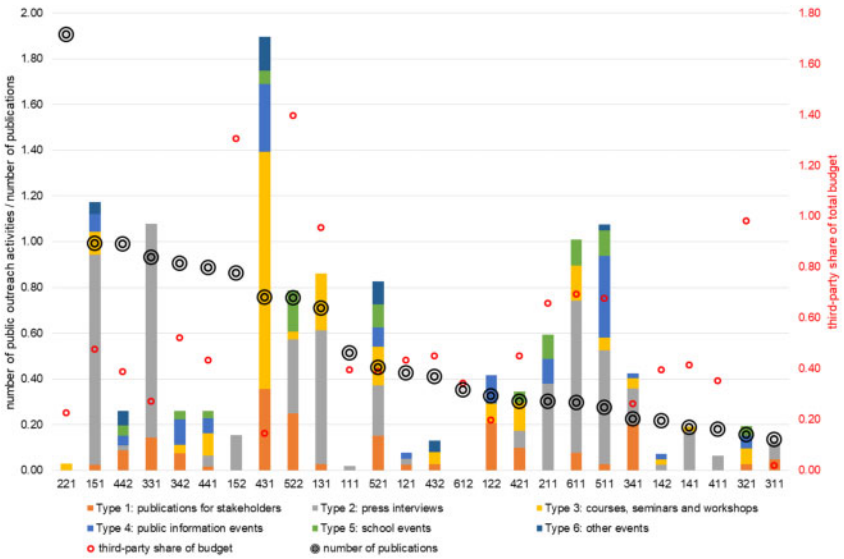

Figure 1. Public outreach activities by type and project, compared to number of peer-reviewed journal articles (cumulated over the entire research center operation; weighted by average project team size).

public information events for local or regional authorities or residents (Type 4) and events, courses, or other activities at schools (Type 5), however, with statistical significance in all cases. Almost all other coefficients of the covariates show positive and statistically significant correlations with research performance in terms of total citations, similar to the analyses above. In this case, the accumulated FTE of the project leadership (*fte_leadership*) stands out, predicting an increase of 0.563 units in the number of total citations for every additional course, seminar, and workshop for stakeholders outside the scientific community (Type 3). Summarizing, the empirical evidence corroborates that engaging in public outreach activities is positively correlated to total citations. Like above, the regression analyses were also run without the 'xtgee' command to determine the *R*-squared values (not reported in Table). Over the six models, the results indicate the predictors to explain between 17 and 26 per cent of the variance.

6. Discussion and conclusion

Researchers and universities are increasingly requested to translate and proactively communicate their findings to the tax-paying public. However, there is a belief among researchers that the time spent on public outreach activities comes at the cost of their core business, drafting and publishing scientific articles. In view of the prevailing 'publish or perish' mentality in academia, the demand for public outreach activities maneuvers researchers into an intricate dilemma situation.

On the basis of data from a research center in the field of sustainability science, this study investigated how engagement in public outreach activities is related to research performance. The context of a research center was especially suitable for this inquiry as scientific publications and public outreach activities are directly related to each other, as documented in the archival data. At the same time, sustainability science in particular is a field that aims to find solutions for the grand societal challenges of our time, which makes public outreach an indispensable activity for researchers.

Confirming the findings of some previous empirical investigations, this study concludes that there is no per se negative correlation between engaging in public outreach activities and the production of scientific publications. By means of three different types of analyses, this study thus provides further evidence not only that the researcher's dilemma is an 'urban legend', but also that in entails no disadvantage, especially in the context of a research center, to engage in the public dissemination of knowledge in addition to the conduct of research.

And yet, of course, it is not black or white. Not all types of public outreach activities are equally positively related to research performance. With regard to the number of publications, writing publications for stakeholders outside the scientific community (Type 1), organizing public information events for local or regional authorities or residents (Type 4), as well as staging other events (Type 6) has shown to have the strongest effect. Against the fact that these types in particular require substantial efforts in terms of time and organization, these findings are somewhat surprising. Interestingly, the same holds true for the alternative operationalization of research performance, the total citations. These results could be interpreted as meaning that both a cognitive 'translation' activity as well as immediate personal exchange with the public is positively associated with research performance. Thus, the results support the idea of 'productive interaction' (Spaapen and Van Drooge 2011), which assume that 'exchanges between researchers and stakeholders in which knowledge is produced and valued that is both scientifically robust and socially relevant'. According to this approach, the interaction brings added value for both sides, which is reflected in an increased research performance on the part of the researchers rather than in a reduced one. The findings also indicate that the project team size plays a noticeable role (Mostert et al. 2010; van der Weijden et al. 2012), showing a negative correlation with research performance. This may appear obvious, as a larger group needs more coordination, which can come at the expense of efficiency. In contrast, however, the results of the statistical analyses have underlined the importance of taking into account not only the number of researchers, but also the intensity of their participation in the project, using, for example, full-time equivalents (Kassab et al., under review). Another result of the study is that there are indeed gender- and experience-specific effects (Johnson et al. 2014). Controlled for the project team size, the absolute number of women and of Master and Doctoral students has a positive effect in both cases of research

performance and a significant effect in almost all types of public outreach. It seems that women are disproportionately involved in public outreach activities. Likewise, the emerging generation of researchers seems to be increasingly interested in these tasks. This contrasts with previous findings suggesting that public outreach activities were mostly taken care of by the more senior researchers (Bauer and Jensen 2011; Poliakoff and Webb 2007).

6.1 Limitations and further research

This study has a number of limitations, the five most relevant of which shall be discussed. Probably the most central one is the fact that it is not possible to make a final statement about the causal direction of the identified relationship: Does engaging in public outreach activities result in more scientific publications and citations? Or does the generation of more scientific publications increase the chance of conducting more public outreach activities? While there is already theoretical literature to explain both mechanisms, further qualitative micro-level research would be necessary to shed more light on this matter empirically.

Second, while there is a widely-recognized measure for the actual impact of scientific publications, namely citations, there is still nothing comparable with regard to public outreach activities. In this study, only the concrete activities were considered rather than their actual impact. The so-called 'altmetrics' (Bornmann et al. 2019; Costas et al. 2015; Piwowar 2013; Ravenscroft et al. 2017; Robinson-Garcia et al. 2018) could possibly provide a solution to this problem. Altmetrics are 'usually based on activity on social media platforms, which relates to scholars or scholarly content. Typical examples of altmetrics include tweets, mentions in blog posts, readership counts on Mendeley, posts, likes, and shares on social networks such as Facebook and Google Plus' (Bornmann and Haunschild 2017). While the focus on social media to indicate impact beyond academia is a promising way forward, their mainstream use is still largely undermined by a number of methodological issues that scholars of the field are working to resolve (Bornmann and Haunschild 2018a,b; Haunschild and Bornmann 2018).

Third, it was not possible to take into account the varying efforts associated with the different types of public outreach activities on the basis of the archival data. While press interviews are mostly written or co-written by professional journalists, which means little to no effort on the side of the researchers, organizing events with the local population, for example, entails numerous preparatory tasks with varying complexity. A survey among researchers could provide a valid weighting of the associated efforts.

Fourth, the data for the study were collected annually at the project level and not at the level of the individual researchers. Although there are indications that this type of analysis makes more sense at project team level (Mostert et al. 2010), mainly because of the division of labor, it would certainly be worthwhile to conduct a comparable study at the level of individual researchers.

Last and fifth, the study is based on data from a specific case of a research center in Switzerland, a highly developed and competitive country. Needless to say, this limits the generalizability of the results per se. Further research, for example, in the form of other case studies, would be required to see whether the pattern holds true in other countries, world regions, and academic systems. However, the results of the present study form a building block in the entire discussion about the relationship between scientific- and publicly-oriented output, as well as in the discussion about the evaluation and impact assessment of research centers.

6.2 Policy recommendations

The results of this study have raised further contentions about the researcher's dilemma described above: there is no negative correlation between research performance and engagement in public outreach activities. With this study, the question of the dilemma was investigated for the first time in the context of a research center. But this insight alone will not be sufficient to resolve it. What is rather needed is a cultural shift and opening of the academic evaluation system, as prominently exemplified by the forthcoming UK's 2021 Research Excellence Framework (REF). 'Impact', one of the REF's three underlying criteria, assesses 'reach and significance of impacts on the economy, society, culture, public policy or services, health, the environment or quality of life' and carries a weight of 25 per cent (REF 2019). This decision succinctly shows how research policy and research funding organizations can play a crucial role toward that shift. In times of global academic competitiveness, however, concerted action is required to make the cultural change happen in a systemic way. Because, as long as engagement in public outreach activities is not explicitly part of an assessment or academic promotion practice, researchers will continue to refrain from investing much time in them, regardless of whether they are intrinsically motivated or asked to do so solely for accountability reasons.

Note

1. For a more detailed description, please refer to Kassab et al. (2018).

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