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Researchers' approaches to stakeholders: Interaction or transfer of knowledge?

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ABSTRACT

Stakeholder interaction is important for enabling environmental research to support the societal transition to sustainability. We argue that it is crucial to take researchers' approaches to and perceptions of stakeholder interaction into account, to enable more clarity in discussions about interaction, as well as more systematic interaction approaches. Through a survey and focus group interviews with environmental researchers at three Swedish universities, we investigate the effects of two models of stakeholder interaction, as well as high and low levels within each. The 'transfer model' implies that interaction is understood as communication and should be separated from research. The 'interaction model' implies that interaction happens throughout the research process. Our study shows some significant differences between researchers in the two models, but also between high and low levels of stakeholder interaction regardless of model. The result indicates that the transfer model needs to be considered in studies and practice of stakeholder interaction, but also that the low levels of the interaction model consists of a number of different types of approaches. The major difference between the two models was about how large researchers understood the benefits and risks with stakeholder interaction to be. Transfer researchers saw interaction as a threat to the integrity of research, whereas interaction researchers saw it as enabling research.

1. Introduction

Interaction between scientists and stakeholders has received increasing attention both in society and in research (Cornell et al., 2013; Cvitanovic et al., 2016; Hulme, 2014; Marshall et al., 2017; McNie, 2007; Varner, 2014; Young et al., 2014). Stakeholder interaction is often regarded as crucial for the production and communication of salient, credible and legitimate knowledge (see Kunseler et al., 2015) not least for the mitigation of environmental problems. Governments, for example, in the UK and Sweden, have created policies to increase the use of scientific knowledge in policy-making (Davies, 2008; Dilling and Lemos, 2011; Phillipson et al., 2012). To achieve this, stakeholder interaction is seen as a crucial tool. The UK is leading this development with demands on scientists of reporting their societal impact. Other Western countries, including the EU, are following suit with funding bodies requesting stakeholder interaction as a necessity for funding.

A first assumption underlying these developments is that the purpose of stakeholder interaction is to increase knowledge use. A second assumption is that certain forms of interaction are better at generating knowledge use. These assumptions can be found, for example, in research on 'what works' in terms of improving knowledge use (e.g. Cvitanovic et al., 2016; Reed et al., 2014; Marshall et al., 2017). Although this research is highly valuable in providing empirical knowledge and guidance to improve stakeholder interaction, it neglects important aspects, which we argue are crucial for efforts to improve interaction and its possibilities to generate more knowledge use. Firstly, researchers interact with stakeholders also with purposes other than increasing knowledge use. A lack of understanding of these motivations may lead to misguided requests and support. Secondly, there are many different ways of conducting stakeholder interaction (see e.g. Mitton et al., 2007). As many of these are connected to how research is conducted, for example, to involve stakeholders early in research projects, 'what works' is dependent on what research approaches that researchers find sound. There is limited knowledge on how researchers perceive these issues, including their motivation for interacting and how this relates to their research practices. Our study is aimed to provide such knowledge.

In this study, we present empirical data on environmental

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researchers' approaches to stakeholder interaction and how they perceive drivers of and barriers to interaction. We use two stylized models of stakeholder interaction, the transfer model and the interaction model, in the categorization and analysis of our data. In particular, we wish to study

1 how researchers understand and work with stakeholder interaction, and if this is connected to the two models of stakeholder interaction, and
2 how the model for stakeholder interaction affect researchers' perceptions of drivers of and barriers to interaction.

A better understanding of how environmental researchers comprehend and work with stakeholder interaction can enable a more comprehensive and systematic way to deal with it, including the requests of and support for stakeholder interaction by a number of different actors, such as funding bodies, universities, and governments. More fundamentally, given these demands, it can also guide researchers to find an approach that suits them and their research. In turn, this enable better interaction and thereby provides the foundation for scientifically informed decisions.

This study contributes empirical knowledge on the perceptions of researchers and in what way the choices they make about stakeholder interaction are associated with the different models. It also contributes theoretically by drawing together different literatures on the science-society interface. The article expands our knowledge on how environmental research can affect policy-making and how this interaction can be made more systematic. The empirical basis of the article is a survey and focus group interviews with environmental researchers at three Swedish universities.

2. Theory

We define stakeholder interaction as the activity in connection to a research project of involving and communicating with actors, who have an interest in the research topic and/or who stand to gain or lose from a possible policy or societal change that might be influenced by the research findings. Thus, it includes a wide variety of practices, from communication of results to co-production of knowledge. Some of these practices are universally accepted by the research community, whereas others are highly contested and associated with certain scientific approaches. In the latter category, different forms of co-production, action research and transdisciplinarity can be included.

There is a rich and growing literature on the science-society interface (see e.g. Spruijt et al., 2014), including research on (1) knowledge use (e.g. Brown, 2012; Davies et al., 2000; Weiss, 1979), (2) critical perspectives (e.g. Hoppe, 2005; Pregernig, 2014), and (3) methodologies of knowledge production, including transdisciplinarity and co-production (e.g. Jahn et al., 2012; Moser, 2016). There are also several studies on the different types of advisory roles that scientists can take (Pielke, 2007; Rudd, 2016; Spruijt et al., 2016; Turnhout et al., 2013; van der Hel, 2016). These studies find different numbers of roles (usually four to five), depending both on the questions included in the study, but also on the investigated population. However, the roles found in these studies are not fully applicable in our case. The reason is they foremost consider stakeholder interaction as an activity of giving advice and they do not pay enough attention to other motives, which we are interested in, as included in, for exampel, action research. Another difference between these studies and ours is that most of them only study perceptions, whereas we also study self-reported practices.

Earlier research has shown that scientists' perceptions about stakeholder interaction can be placed along a continuum from a so called traditional view—speaking truth to power—to a more collaborative view (e.g. Rudd, 2015; van der Hel, 2016). We understand the two models used here as broad families of perceptions, with internal variation from moderate to extreme positions. However, we argue that in terms of research practices they capture an important distinction between the perceived need to insulate scientific knowledge production from stakeholder influence (in 'the ivory tower') or if such influence is seen as valuable. As this difference is often present in discussions of science and its role in society, it is worth investigating how it actually translates into perceptions and practices of stakeholder interaction—thus connecting the advisory role to research practices and methodological considerations.

In the ideal typical *transfer model* of stakeholder interaction (see e.g. Calow, 2014; Davies, 2008), knowledge is seen as a product that can be transferred from researchers to stakeholders. Interaction is not understood as a process where several parties need to be active, but foremost as one-way communication. Scientific authority is perceived as resting on the neutrality, or disinterest, of researchers (see Hoppe, 2005; Merton, 1973). It, thus, becomes crucial to separate the activity of *producing* knowledge from that of *communicating* knowledge. Within this model, stakeholder interaction is focused on the communication (or transfer) of research results, mainly after research is done. It is often described as a "linear" model (e.g. Young et al., 2014), in which stakeholders do not (and should not) influence research. Even if this model does not seem to contain any actual *inter*action, we include it as a model of stakeholder interaction, as it represents one sort of contact scientists have with stakeholders.

The ideal typical *interaction model* of stakeholder interaction (see Calow, 2014; Davies, 2008), builds on a very different perception of science and its role in society. Stakeholder interaction is seen as a process where researchers and stakeholders can be active throughout the research process. Scientific knowledge is not seen as authorative because scientists are objective and without interests, but because transparent methods and systematic analysis are used. There is, thus, less need to clearly separate knowledge production and communication to protect the integrity of the research process and the resulting knowledge. The model enables interaction throughout the research process and beyond, which opens up possibilities for more including research methodologies (Cornell et al., 2013; Jahn et al., 2012; Jasanoff, 2004).

We use the two models in our analysis of how researchers interact with stakeholders during problem formulation, knowledge production, and communication of results. In the transfer model, interaction is foremost seen as part of the communication phase, whereas in the interaction model interaction take place in all phases, see Fig. 1.

In the *problem formulation* phase, the problem is formulated and

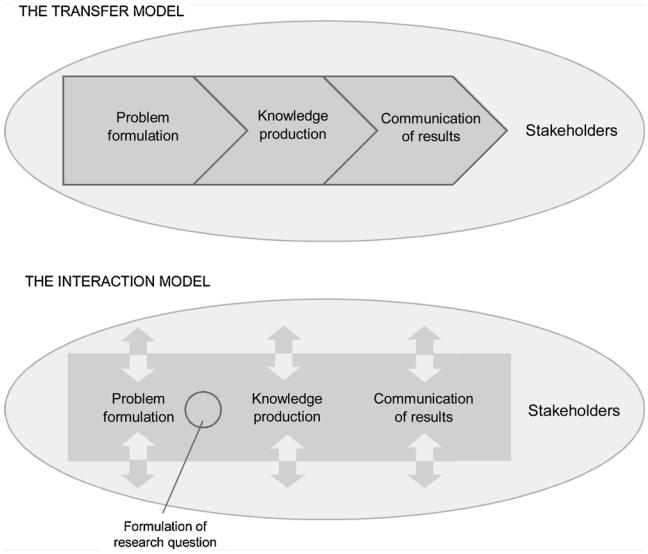

Fig. 1. Two models of stakeholder interaction (dark grey corresponds to science, light grey to stakeholders).

more specific research questions articulated. In the transfer model, this phase should be free from societal influence to enable sound research. In the interaction model, researchers and stakeholders, to increase the research salience, yet maintaining the scientific relevance, can formulate problems jointly, but leave the articulation of research questions to researchers (e.g. Jahn et al., 2012). In the *knowledge production* phase, stakeholders can be used as sources of data (through surveys, interviews, or experiments) in both models. Within the interaction model, stakeholders can also give feedback on the research direction and choices, and take active part in knowledge production (see e.g. Glassman and Erdem, 2014), which is not the case in the transfer model. The *communication* phase is similar for both models. In this phase, research results are communicated to stakeholders and/or the public to increase awareness and influence decisions and practices.

To what extent research practices are guided by these models is an open question. We are here not interested in the entire universe of perceptions, but rather in the major differences between the transfer and interaction models.

3. Material and method

A mixed-methods approach was used, including a quantitative survey and qualitative focus group interviews. The purpose of the survey was to study how stakeholder interaction was understood and test the models' influence on how interaction was conducted and how drivers of and barriers to interaction was perceived. Focus group interviews complemented the survey with a deeper understanding of the reasoning behind the models and the researchers' perceptions about drivers and barriers.

3.1. The survey

The electronic survey was sent to 1567 researchers in environmental science and related disciplines at the University of Gothenburg, Chalmers University of Technology, and Lund University, Sweden, from June to August 2015. All researchers connected to a network or department that fully or partly work with issues connected to sustainability issues were targeted. The number of respondents was 331 (21%, see Table A1). Descriptive statistics for the respondents are presented in Table 1.

The first part of the survey explored to what degree, at what phases of the research process, and how researchers interact with stakeholders. The second part included questions exploring what barriers to and drivers of stakeholder interaction researchers perceive as important. The respondents were asked to rate the most important factors for and against engaging in stakeholder interaction among a set of alternatives, but could also specify other alternatives. The third part of the survey asked for information on the respondents' age, title, gender and type of research field (see Table A2).

Following the theoretical assumptions made about the models, they were assigned based on respondents' ratings of their degree of interaction with stakeholders during the phases of problem formulation, knowledge production, and communication of results. Respondents could rank the phases between 1 (no interaction) and 5 (high interaction). They were classified using Boolean logic on the rates for problem formulation (A), knowledge production (B) and communication (C), as follows:

Transfer model: $C > \max(A,B)$ AND $\max(A,B) \leq 2$

Interaction model: $\max(A,B) \geq C$ OR $\min(A,B) \geq 3$

For the transfer model this means that the respondent needs to rate stakeholder interaction as highest in the communication phase, combined with a low (2) or non-existing (1) interaction of the other two phases. In order to be associated to the interaction model the respondent needs to rate (i) problem formulation and/or knowledge production as equal as or higher than communication, and (ii) all three phases as 3 or above, regardless of communication level. This is consistent with an understanding of researchers in the interaction model as not having to protect research from stakeholder influence.[1] Only one combination (1-1-1) was excluded with this classification, with only one respondent. This respondent was removed from further analysis, together with respondents stating they had no overall stakeholder interaction. In total, 33 respondents were removed, leaving 293 for further analyses.

We further differentiated between respondents with high and low degree of stakeholder interaction within each model. A high degree of interaction was assumed to prevail when $C > 3$ for someone belonging to the transfer model and when $\min(A,B,C) \geq 3$ for someone belonging to the interaction model. Classifications on all combinations that someone responded are provided in Table A4.

Within each of the four groups, we tested for control variables that could explain the pattern of interaction, more specifically the research field, researcher's attributes and type of stakeholder interaction (decision closeness, types of stakeholders). We further tested for differences in how the two groups conducted interaction, and what drivers and barriers were seen as important for interaction. Testing was done by analysis of variance of generalized linear models for each factor (control variable, factor, driver or barrier) with "model" ('transfer' and 'interaction') or "level" ('low',' high') as explanatory variables. Thus, for each factor we fitted a full GLM (with model, level and interaction terms), and two simple GLM (one with model and one with level as terms). Associations were estimated using the GLM model with the lowest Akaike Information Criteria. The factor for each GLM model was tested using a Likelihood Ratio test on deviances. Factors with a p-value less than 0.005 (adjusted from a significance level of 0.05 for multiple

Table 1
Descriptive statistics for the respondents (N = 331). For discipline and research area respondents could give more than one answer. For the disciplinary alternative 'other', several stated engineering.

		% (N = 331)
Gender	Male	54 (179)
	Female	44 (146)
	N/A	2 (7)
Academic title	PhD students	34 (112)
	PhD	27 (91)
	Associate professor	12 (41)
	Professor	22 (72)
	Other	4 (13)
	N/A	1 (2)
Discipline	Natural science	54 (179)
	Social science	18 (59)
	Humanities	1 (4)
	Interdisciplinary research	39 (129)
	Other	8 (27)
	N/A	1 (3)
Research area	Biodiversity conservation	17 (57)
	Climate change	55 (182)
	Ecosystem based management	17 (57)
	Economics	12 (39)
	Ecosystem services	22 (74)
	Environmental law	2 (8)
	Environmental politics	17 (57)
	Environmental risks	34 (112)
	Health risks	13 (42)
	Mathematics	0 (0)
	Natural resources management	31 (101)
	Philosophy	3 (9)
	Physic-geochemical processes	8 (27)
	Pollution	27 (89)
	N/A	2 (5)
Age	Range 25 to 73, median 39, mean 42	

[1] Respondents also ranked their stakeholder interaction in a fourth phase—to get data. This was done to differentiate interaction during knowledge production from interaction only to get data.

testing) were seen as having a statistically significant association to model or level of stakeholder interaction.

3.2. Focus group interviews

Two focus group interviews were conducted; one in Gothenburg with five participants, and one in Lund with four participants. The participants were active researchers or emeriti in fields related to environment or sustainability and came from several different disciplines. They were chosen based on their interest in some aspect of stakeholder interaction. We aimed for diverse groups in terms of perspectives, disciplines, gender, and age (see Then et al., 2014). The group in Lund, due to last minute cancelations, included only men.

Focus groups provide possibilities for studying deeper levels of meaning, connections and nuances through the interaction in the group (Stewart et al 2007), which was crucial for our purpose. To produce a rich material, the groups need to be managed to ensure discussions are on topic and that dominant individuals do not take over (Then et al., 2014). In our case, this was ensured by the diversity in the groups, the rather low number of participants, and an active moderator. Importantly, focus groups cannot be used for generalizations to a larger population (Stewart et al 20017). Our purpose is to nuance the understanding of different approaches to stakeholder interaction, and not to draw conclusions on how common they are. The participants were provided a number of open-ended questions in advance (see Table A3). The interviews were two and a half hours long and semi-structured. At each session, two project researchers were present. One of them moderated the interview, kept track of time and ensured that all issues were discussed. The discussions were recorded and transcribed.

The transcribed discussions were analyzed thematically. In the first round of analysis, the utterances of the participants were coded and sorted into different themes[2] . The themes were derived from the discussions, following focus group method (Stewart et al., 2017). In a second round, the utterances within the themes were analyzed to capture their connection to the models of stakeholder interaction. In one of the groups, both models were present, whereas in the other only the interaction model was. We did not assess how high or low their stakeholder interaction was. The result from the two groups is presented jointly.

4. Results

All stakeholder interaction groups ('high interaction', 'low interaction', 'high transfer', 'low transfer') contained respondents, with the interaction model being more common, see Table 2.

The distribution of stakeholder interaction over the research process within the four groups are distinctly different (see Fig. 2). The 'low interaction' group has the largest internal variation and overlap to the other groups. This is consistent with our more strict decision rule on the transfer model, and the more inclusive one for the low interaction model. This group incorporates different interaction profiles, including very low responses (e.g. 2-1-2), medium responses (e.g. 2-3-3), low on problem formulation, high on knowledge production and communication (e.g. 2-4-5), and high on problem formulation and communication, low on knowledge production (e.g. 3-1-4). The other three groups are more homogenous in terms of profiles. Thus, the low interaction group can be seen as a mixed group, with mixed practices and perceptions.

4.1. Researcher characteristics, type of stakeholder and channel

The results from statistical testing on all factors are found in Table A5. Among the control variables, higher age (LR p-value < 0.001) and academic title (LR p-value < 0.001) was higher in the interaction model and with high overall level of stakeholder interaction within both models (see Fig. 3). Respondents with high levels of interaction saw their research as more oriented to a decision context, compared to respondents with lower level of interaction (LR p-value < 0.001). There were no significant results for gender and disciplinary affiliation. The respondents interact with a wide span of stakeholders. Among these, the business community was associated with a higher degree of stakeholder interaction, and with the interaction model compared to the transfer model (Fig. 3, LR p-value < 0.001). Stakeholders from non-governmental organizations were more important for respondents with 'high transfer' than 'low transfer' (LR p-value < 0.001). It was more common to find stakeholders from the public in the transfer model compared to the interaction model (LR p-value = 0.001).

The most common channel (among printed material, social media, and meetings) for respondents to interact with stakeholders was social media, which 202 respondents answered they used very often for this purpose. The next most common interaction channel was printed material. Among channels, the use of meetings were different between the models and were more associated with the transfer model and with lower levels of interaction (LR p-value 0.005, although slightly on the significance level adjusted for multiple testing we report this result since it was significant after controlling for outliers in the analysis).

Table 2
Number of respondents classified as having high/low degrees of stakeholder interaction, and as belonging to the interaction/transfer model.

	High	Low	N
Interaction	110	132	242
Transfer	21	30	51
N	131	162	293

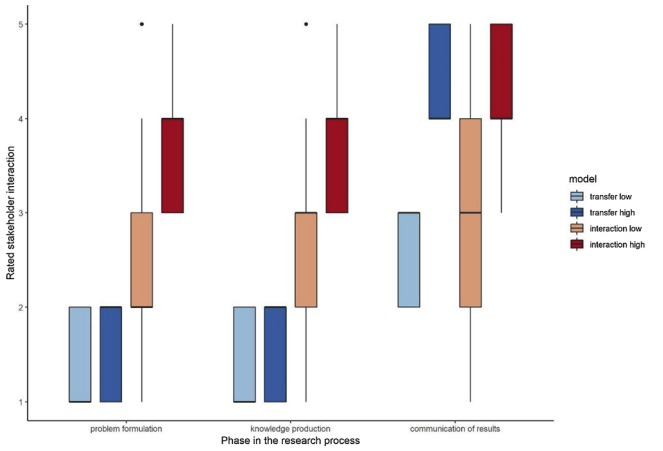

Fig. 2. Boxplots of rated level of stakeholder interaction for three phases during the research process for the transfer and interaction model and with low and high degree of stakeholder interaction.

4.2. Influence of the two models on researchers' perceptions

The analysis of researchers' perceptions on drivers and barriers, could confirm some differences between the two models, and between high and low levels of stakeholder interaction (see Table A5). Four factors with statistically significant differences between the models and the levels of stakeholder interaction are presented in Fig. 4. The driver to 'spread knowledge' was more associated to the transfer model (LR p-value = 0.003). The driver 'funders demands it' and the barrier 'lack time' were more associated to lower levels of stakeholder interaction regardless of model (LR p-value 0.004; LR p-value 0.003). In addition,

[2] 'Reasons to do stakeholder interaction'; 'scientist-stakeholder relations'; 'when in the research process'; 'who should do it'; 'possibilities'; 'risks'; 'which stakeholders'; 'problems doing stakeholder interaction'; and 'how to do it'.

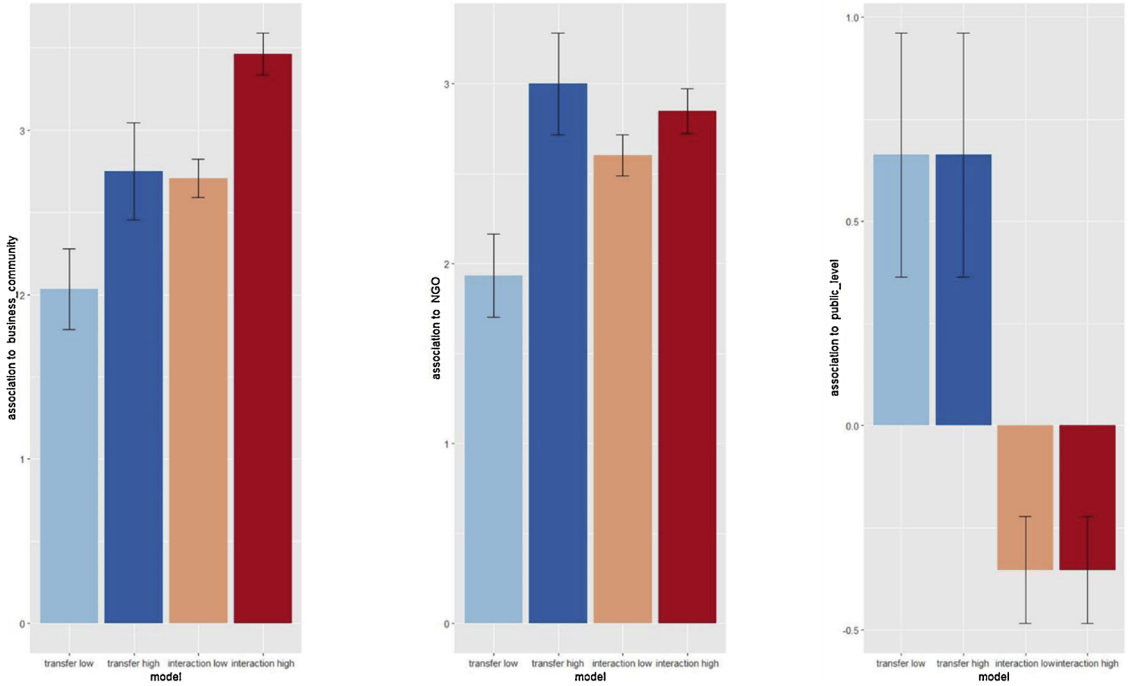

Fig. 3. Estimated association to stakeholders with statistically significant differences over the model or level of interaction for a) business community, b) NGO and c) the public (only association to model for interaction).

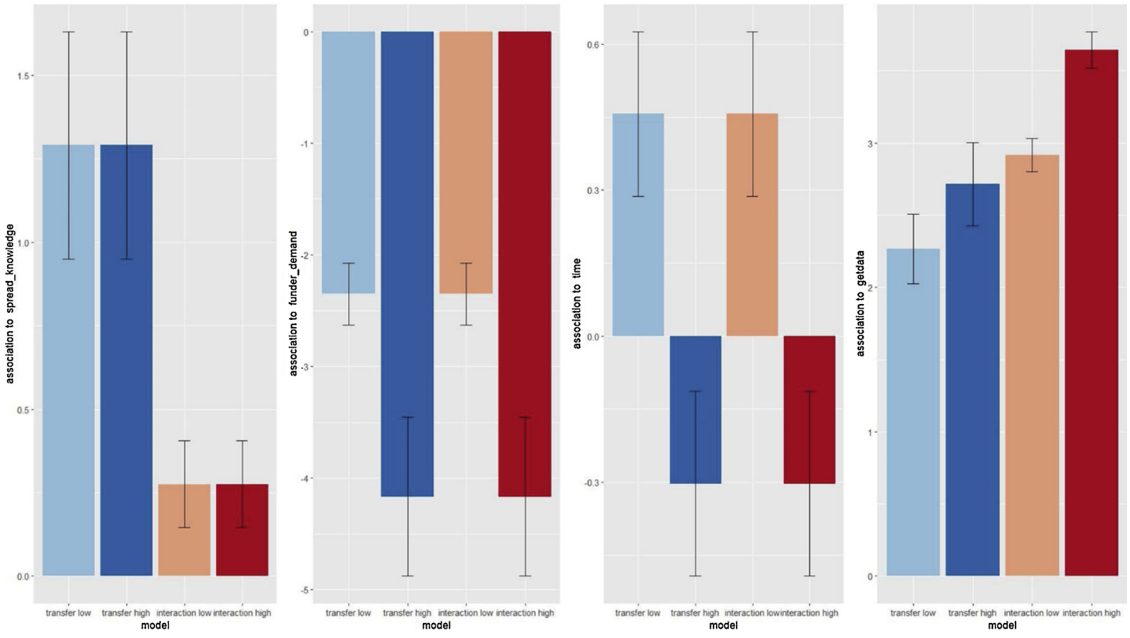

Fig. 4. Estimated association to drivers and barriers with statistically significant differences over the model or level of interaction for a) *spread knowledge* (only model significant), b) *funder demands it* (only level significant), c) *lack time* (only level significant) and d) *to get data* (both model and level significant).

respondents with high levels of interaction in both models, and in particular in the interaction model, had rated their level of interaction 'to get data' higher compared to the other groups (LR p-value < 0.001), leading us to interpret it as a driver of stakeholder interaction.

The result from the focus groups supports the result of the survey, with notable exception, and further distinguishes between the two models, discussed below.

4.2.1. The transfer model

One perception, associated with the transfer model, voiced in the focus groups was the need to separate different tasks in the research process. Stakeholders can be involved in the research process to give data or as receivers of information, but not to affect the direction of research projects. This was seen as the prerogative of researchers and crucial for protecting the scientific integrity and quality of the project.[3]

> …when we are doing a research project, we need a closed room without the stakeholders to be able to have an open discussion about where we are; what studies went wrong?; why did they go wrong?;

[3] All citations come from the transcriptions of the focus group interviews.

how can we improve things?; what are the weak spots? As soon as there are stakeholders involved … scientists change their behavior.

Independence of the researcher and the research project is thus necessary, and too much contact with stakeholders should be avoided. The risk is otherwise to lose the independence of the research, or that society perceives its independence as crippled.

I have said no to be part of a couple of advisory boards because I have made the calculation that being seen in that context may mean that people may assume that my research results are affected or associated with this.

The division also needs to be upheld in the communication phase. Giving advice is seen as something distinctly separate from presenting results, and was avoided. Further risks discussed were that the reputation of researchers can be effected negatively, that it takes time from other tasks and can thus negatively affect the research, and that research, at large, is steered in particular directions. Researchers are seen to be without stakes of their own in the issues studied:

The conflict of interest is something that a pure colleague, or other researchers or peers don't have. There isn't a pure interest or an agenda. … [T]hey don't have a stake in it. But with a stakeholder, there is an interest and an agenda there…

When conducting stakeholder interaction, a clear separation between researchers and stakeholders is necessary, as well as between knowledge production and communication. Further, stakeholder interaction is seen as steered by researchers. It is when researchers need input in form of data, or when the project is finished that interaction takes place. The most important reason to interact with stakeholders is that research funders demanded it.

Especially when you are doing research that has anything to do with the environment, you are basically not allowed to do research without having stakeholder interaction. The slogan that the European commission gave is; 'no science for the sake of science', and they were very proud of it. I'm not sure that I like that. But it doesn't matter whether you like it or not, you still have to apply to it.

However, in the survey results this was not connected to the model of stakeholder interaction.

Taken together, interaction is perceived as something that is added on to research, not connected to what research is about, which corresponds to the 51 respondents with stakeholder interaction profiles within the transfer model. Focus was on the need to keep research and stakeholder interaction as separate processes and on the risks when this could not be achieved. As long as the boundaries between science and society are kept intact and tasks clearly separated, stakeholder interaction is seen as beneficial for research.

4.2.2. The interaction model

An approach associated with the interaction model was also voiced in the focus groups. Crucial here was the perception that stakeholder interaction is needed to enable research and make it relevant. It provides necessary information about the context of a project and can provide insights, otherwise not available to the researcher. This supports the correlation in the survey between the interaction model and 'get data', as it can be related to this need to interact to get access to material. In the focus groups it is clear that it even can improve the quality of research.

I have seen it as a method, to be of assistance to the companies that we studied, to help them with some aspects in order for us to get better contacts and deeper knowledge about how it really looks. It is a prerequisite to make them open up … You could say that we have been steered in a way, but I don't think that, because we have been able to focus on our research questions, what we were interested in. […] We have learnt from that and have discovered other research questions.

Further, interaction is seen as something that is part of the entire research process, echoing the interaction profiles of the 242 respondents in the interaction model in the survey results.

It should be underlined that interaction can be present in all these steps [of the research process]. There is a tradition among some that interaction should only come into the last step. It is important to start earlier. I don't think it's a bad idea to have it in the two initial steps [problem formulation and knowledge production]. The research problem can come from above, but then the research question needs to be formulated in a scientific way.

A major difference to the transfer model is how the relation between researchers and stakeholders, or society, is understood. It was emphasized that researchers are part of society and that they have interests as any other stakeholder. This was not seen as a threat to the integrity of research projects, but rather as a reason to interact and include stakeholders throughout the research process. Research is understood as a mutual process, where researchers and stakeholders alike stand to gain. As interaction is seen as an important part of doing research, not an add-on, a clear division between tasks is less important. The mutuality also implies that interaction is not only conducted on the request of researchers, but also steered by the needs of stakeholders.

Focus in the interaction model is directed at how interaction can be conducted and on problems while doing it. For example, one problem is that research with extensive involvement of stakeholders is difficult to publish in high-ranking journals. Another issue is how to get stakeholders interested and involved, especially early on in projects.

Taken together, the utterances concurrent with the interaction model were focused on practicalities of how to do it and how to solve problems. Benefits were seen as large and risks as manageable. The reason why it is seen as necessary and logical to interact with stakeholders throughout research projects, is that knowledge production is perceived to be dependent on it, and that this process does not threaten the integrity of the research.

5. Discussion and conclusions

Based on the results from the survey and the focus groups we conclude that the transfer and interaction models represent two different ways researchers understand their stakeholder interaction. Despite the limited interaction present in the transfer model (in the form of communication), some of the survey respondents and focus group participants saw this as stakeholder interaction. Turnhout et al. (2013) have come to similar conclusions (see also Calow, 2014; Spruijt et al., 2016). Earlier qualitative research (e.g. Davies, 2008) has indicated that the transfer model is more common than the interaction model. The result of our survey indicates opposite. However, this is likely a result of the strict decision rule for the transfer model and the rather inclusive one for the interaction model, particularly for respondents with low scores. Our differentiation into high and low degrees of stakeholder interaction can partly capture the wider variety of groups found in other studies (Pielke, 2007; Rudd, 2016; Spruijt et al., 2016; Turnhout et al., 2013; van der Hel, 2016). For example, the group 'low interaction' relates to 'science arbiters' in a study by Turnhout et al. (2013), whereas the group 'high interaction' is partly captured by 'participatory knowledge producers'. Spruijt et al. (2016) find three groups that in our study relates to the interaction model, although not clear if to the 'low interaction' or 'high interaction' group. There is a need to differentiate between groups within our 'low interaction' group (as other studies do), but also to consider researchers that see stakeholder interaction as transfer of knowledge (as our study shows).

In terms of how stakeholder interaction was conducted (stakeholder type, channels used etc.), there were some significant results. That the

business community is more important in the 'high interaction' group can be related to that these respondents also saw themselves as closer to a decision context. Working together with business actors for innovations could be one type of such interaction. Meetings with stakeholders were more important in the transfer model, as well as among those with low degrees of stakeholder interaction. This seems counter-intuitive, but can depend on what respondents understood as 'meetings'. Even if there was few differences in terms of stakeholders and channels used, the difference in terms of approach was still fundamental, as was evident in the focus groups. Within the transfer model, interaction with stakeholders were seen as a potential threat towards the integrity and quality of research. It was further seen as something that takes time from more profound tasks. Researchers felt they needed to separate stakeholder interaction from their other tasks. Within the interaction model, researchers did not feel a need to separate tasks in the same way in order to protect scientific integrity and quality. Instead, quality was seen to improve with interaction, which earlier studies (Varner, 2014) support. Haynes et al. (2011, 1053) found that researchers with a strong focus on stakeholder interaction did not see themselves as a "detached and impartial traditional scientist". There seems, thus, to be a clear difference between the perspectives of researchers within the two models, supported both by our and earlier studies. Even if the models are stylized and oversimplified, hiding much variation, it still seems like the 'linear' model of the science-society interface has impact over how some researchers understand and conduct stakeholder interaction. That higher age was positively associated with the interaction model indicates that with more experience researchers can shift from a transfer to an interaction model. However, as higher age also correlated positively to overall high levels of stakeholder interaction, more experience does not need to mean a shift to the interaction model. A shift from transfer to interaction based on experience is also countered by PhD students as the academic title group with strongest association to high levels of interaction within both models. This could indicate that the stakeholder interaction debate over the last years have influenced PhD students to interact more, but not influenced under what model. Other large-N studies have found age and academic title to have no influence (Rudd, 2016; van der Hel, 2016). This could depend on regional differences, but also on the focus of their studies.

When it comes to drivers and barriers of interaction, the survey proved fewer differences between the two models than expected. The driver to 'spread knowledge' was a more important reason for interacting with stakeholders in the transfer group, concurring with the theoretical foundation of the model. The reason for the association of the driver 'funder demand it' to a high level of stakeholder interaction is unclear, but could depend on what projects these researchers seek funding for. To 'get data' was significant both for model (the interaction model) and for level (high stakeholder interaction). In the focus groups, researchers in the interaction model emphasized that the possibility to conduct studies in some cases was dependent on interaction. This could be one explanation for the survey result. Generally, the result from the focus groups indicated that researchers within the interaction model perceived drivers as much stronger than did researchers within the transfer model.

The survey proved only one significant barrier to stakeholder interaction—'lack of time', which was a more important obstacle for respondents with low levels of stakeholder interaction in both models. More experience seems to decrease the feeling that interaction is time consuming, even if the more experienced researchers interact more. Based on the focus groups no differences between the two models in terms of type of barrier could be found. However, there was a clear difference in terms of how limiting the obstacles were seen to be. For example, whereas transfer model researchers saw the negative impact of stakeholders' agendas as a major threat and a reason not to interact with stakeholders, interaction model researchers saw it as a serious problem that needs to be managed. We could not detect the differences between models found in the focus groups on benefits and risks with stakeholder interaction. In our survey, respondents were not asked to rate the importance of drivers and barriers, preventing this from being detected. Future research needs to consider in what way drivers and barriers are important to researchers.

These conclusions show the importance of considering how different epistemological and methodological issues relate to perceptions on and practices of stakeholder interaction. Increased awareness about these differences on all parts—researchers, universities, and research funders—could decrease confusion in public and academic discussion, but also enable a better tailored support system from universities and generate clearer demands from research funders. More importantly, researchers need to consider the reasons why they want to interact, before they can decide when and how to actually do it. This knowledge enables a more systematic approach to stakeholder interaction by research funders, universities and researchers alike.

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Declaration of interest

None.

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Appendix A

Table A1
The number of recipients of and respondents to the survey based on university. It is not possible to separate respondents from the University of Gothenburg and Chalmers University of Technology, as researchers are part of the same networks (through which the survey was distributed).

	Gothenburg University/ Chalmers University of Technology	Lund University	Total
Number of recipients	500	1076	1576
Number of respondents	157	174	331
Percentage of recipients responding	31	16	21

Table A2
Survey parts, questions and alternatives. In some cases the wording has been condensed compared to the distributed survey.

PART 1	Rate the degree of interaction you generally have with stakeholders connected to your research.	1-5 (1 no interaction; 5 very high degree)
	Rate the **degree of interaction** you have with stakeholders during the different **stages of a research process**.	1-5 (1 no interaction; 5 very high degree) for each of the following: Problem formulation; data collection; know-ledge production; communication of result
	Which **categories of stakeholders** are the most important for your current research? Rate the degree of interaction	1-5 (1 no interaction; 5 very high degree) for each of the following: Politicians; civil servants; business/individual companies; non-governmental organizations; researchers; the public; other
	What **level/s of society** do you wish to influence with your research?	Global; EU; national, regional, local, the public; no particular level; other
	How often do you use different **channels** of SI?	Yes very often; yes sometimes; no never; for each of the following: Printed material; social media; meetings
	Follow up 1: Specify what kind of **printed material**.	Policy briefs; academic publications; media material; newsletters; popular science, other
	Follow up 2: Specify what kind of **social media**.	Twitter; facebook; blogs; other
	Follow up 3: Specify what kind of **meetings**.	Interviews; group discussions; focus groups; workshops; expert elicitation; surveys; other
	Do you interact with stakeholders in a way, which has not been mentioned?	Yes; no
PART 2	What statement/s best corresponds to your opinion of the **purpose of stakeholder interaction**? Note that you can choose two statements maximum.	SI is a method to learn about my stakeholders' needs/ issues/context; SI is a method to spread the knowledge from my research; I interact because research funders demand it; I am not interested in knowing what my stakeholders think of my research; If successful, stakeholder interaction will increase the quality of my research; other
	What **hinders** you from successfully interacting with stakeholders? Note that you can choose more than one statement.	I lack time to prioritize SI; I lack finances for SI; I do not know how to get in contact with my stakeholders; I do not feel encouraged to interact with my stakeholders; I do not know how to successfully conduct SI; other
	What **encourages** your stakeholder interaction?	Free writing
PART 3	**Academic title**	PhD student; PhD, Associate Professor; Professor, Other
	Year of PhD	Specify year
	What is your **research** categorized as?	Social science; natural science; humanities; interdisciplinary; other
	What **issue/s** do your research primarily concern? Note that you can choose several answers.	Climate change; environmental risks; pollution; health risks; natural resources management; ecosystem based management; biodiversity conservation; ecosystem services; physic-geochemical processes; economics; environmental law; environmental politics; mathematics; philosophy; other
	Rate to what extent your research is close to a **decision oriented focus**.	1-5 (1 no focus; 5 high focus)
	Gender	Male; female
	Age	Specify a year

Table A3
Questions sent out in advance to participants in the focus groups.

Themes	Questions
Reasons for interaction with stakeholder	How did you start interacting with stakeholders? What were the most important reasons for you to start interacting? Has it changed over time? Why do you interact? Does it benefit you / your research group / your department?
How to interact	What methods /approaches have you used to create and develop interaction? How has your interaction developed over time?
Reasons not to interact / barriers to interact	What makes you avoid interaction at times? What makes interaction fail? What are your experiences? What arguments have you encountered against interaction? Within and outside of academia? What actors and structures do you see as the major obstacle to more/better interaction?
How interaction can be developed	If you would council universities, funders and policy-makers about interaction, what would you say? What can be done within the PhD education and within research groups to encourage interaction?

Table A4
Classification (into model and level) of different rating combinations of stakeholder interaction for problem formulation (A), knowledge production (B) and communication of results (C). Only those combinations that some respondent indicated are included. The number of respondents for each combination is seen in the column frequency (N = 294, of which one was removed). Interaction (i), transfer (t).

A	B	C	Frequency	Model	Level
1	1	1	1	*removed*	*none*
2	1	1	1	i	Low
3	1	1	1	i	Low
1	2	1	1	i	Low
2	2	1	1	i	Low
1	4	1	1	i	Low
3	4	1	1	i	Low
1	1	2	11	t	Low
2	1	2	7	i	Low
3	1	2	1	i	Low
1	2	2	9	i	Low

(*continued on next page*)

Table A4 (*continued*)

A	B	C	Frequency	Model	Level
2	2	2	12	i	Low
3	2	2	2	i	Low
4	2	2	1	i	Low
2	3	2	3	i	Low
3	3	2	3	i	Low
4	3	2	1	i	Low
4	4	2	2	i	Low
1	1	3	6	t	Low
2	1	3	3	t	Low
3	1	3	3	i	Low
4	1	3	1	i	Low
1	2	3	2	t	Low
2	2	3	8	t	Low
3	2	3	2	i	Low
5	2	3	1	i	Low
1	3	3	5	i	Low
2	3	3	9	i	Low
3	3	3	13	i	High
4	3	3	3	i	High
5	3	3	1	i	High
1	4	3	1	i	Low
2	4	3	5	i	Low
4	4	3	4	i	High
5	4	3	1	i	High
1	5	3	1	i	Low
3	5	3	1	i	High
1	1	4	2	t	High
2	1	4	4	t	High
3	1	4	3	i	Low
1	2	4	2	t	High
2	2	4	6	t	High
3	2	4	11	i	Low
4	2	4	1	i	Low
5	2	4	1	i	Low
1	3	4	4	i	Low
2	3	4	13	i	Low
3	3	4	9	i	High
4	3	4	6	i	High
1	4	4	2	i	Low
2	4	4	9	i	Low
3	4	4	8	i	High
4	4	4	14	i	High
5	4	4	3	i	High
3	5	4	5	i	High
4	5	4	1	i	High
5	5	4	1	i	High
1	1	5	2	t	High
2	1	5	1	t	High
5	1	5	1	i	Low
1	2	5	1	t	High
2	2	5	3	t	High
3	2	5	2	i	Low
2	3	5	4	i	Low
3	3	5	5	i	High
4	3	5	4	i	High
5	3	5	1	i	High
2	4	5	5	i	Low
3	4	5	6	i	High
4	4	5	4	i	High
5	4	5	3	i	High
2	5	5	1	i	Low
3	5	5	2	i	High
4	5	5	6	i	High
5	5	5	9	i	High

Table A5
Tests of variables explaining differences between the transfer and interaction models and between low and high level of interaction. For each factor we fitted a GLM with level and model for stakeholder interaction as explanatory variables (including interaction), one GLM with level and one GLM with model for stakeholder interaction as explanatory variables. A Gaussian GLM was used unless the factor was a dichotomous variable (0 or 1), for which a Binomial GLM was used. Factors in bold have at least one p-value less than the Bonferroni corrected significance level 0.0045. Estimates with standard errors of the effect of the model or level of interaction on the factor are provided for the GLM with the lowest Akaike Information Criteria. The p-value for the chosen model is marked in bold.

Factor	LR test			interaction model				transfer model			
	GLM	GLM	GLM	Low level		High level		Low level		High level	
	level & model	level	model	Est	SE	Est	SE	Est	SE	Est	SE
Gender	0.387	0.376	0.241	−0.29	0.13	−0.29	0.13	0.08	0.28	0.08	0.28
Age	0.000	0.000	0.000	41.48	1.04	45.78	1.14	37.50	2.21	39.26	2.68
Academic title	0.001	0.000	0.100	2.12	0.10	2.53	0.11	2.12	0.10	2.53	0.11
Research close to decision context	0.000	0.000	0.024	3.17	0.09	3.63	0.10	3.17	0.09	3.63	0.10
Politicians	0.050	0.014	0.711	2.14	0.10	2.43	0.11	2.14	0.10	2.43	0.11
Civil servants	0.003	0.001	0.175	2.71	0.11	3.12	0.12	2.71	0.11	3.12	0.12
Business community	0.000	0.000	0.000	2.71	0.12	3.46	0.13	2.03	0.25	2.75	0.30
NGO	0.000	0.001	0.023	2.60	0.11	2.85	0.12	1.93	0.23	3.00	0.28
Public stakeholder	0.052	0.024	0.238	2.65	0.10	2.92	0.11	2.65	0.10	2.92	0.11
Printed material	0.601	0.377	0.295	2.04	0.04	2.04	0.04	2.20	0.09	2.20	0.09
Policy briefs	0.810	0.390	0.623	0.29	0.04	0.40	0.05	0.29	0.04	0.40	0.05
Academic publications	0.943	0.918	0.791	0.76	0.03	0.76	0.03	0.71	0.07	0.71	0.07
Media material	0.865	0.815	0.560	0.30	0.03	0.30	0.03	0.41	0.08	0.41	0.08
Newsletters	0.832	0.374	0.890	0.25	0.04	0.13	0.04	0.25	0.04	0.13	0.04
Popular science	0.883	0.486	0.712	0.34	0.04	0.43	0.05	0.34	0.04	0.43	0.05
otherprint	0.957	0.745	0.649	0.14	0.02	0.14	0.02	0.06	0.06	0.06	0.06
Social media	0.671	0.214	0.984	2.71	0.04	2.56	0.05	2.71	0.04	2.56	0.05
Meetings	0.005	0.009	0.014	1.95	0.05	1.62	0.05	2.23	0.10	2.10	0.12
Interviews	0.951	0.964	0.560	0.39	0.03	0.39	0.03	0.29	0.08	0.29	0.08
Group discussions	0.449	0.152	0.668	0.56	0.04	0.74	0.04	0.56	0.04	0.74	0.04
Focus group discussions	0.309	0.147	0.374	0.16	0.04	0.38	0.04	0.14	0.09	0.06	0.10
Workshops	0.836	0.825	0.556	0.76	0.03	0.76	0.03	0.66	0.07	0.66	0.07
Global	0.280	0.098	0.362	0.08	0.16	0.47	0.18	0.08	0.16	0.47	0.18
EU	0.308	0.961	0.179	−0.02	0.13	−0.02	0.13	0.41	0.29	0.41	0.29
National	0.760	0.322	0.650	1.03	0.18	0.78	0.19	1.03	0.18	0.78	0.19
Regional	0.303	0.844	0.098	0.13	0.13	0.13	0.13	0.66	0.30	0.66	0.30
Local	0.646	0.672	0.599	−0.08	0.13	−0.08	0.13	0.08	0.28	0.08	0.28
Public	0.006	0.220	0.001	−0.35	0.13	−0.35	0.13	0.66	0.30	0.66	0.30
Climate Change	0.040	0.590	0.022	0.13	0.13	0.13	0.13	0.88	0.31	0.88	0.31
Environmental Risk	0.896	0.608	0.610	−0.63	0.17	−0.50	0.18	−0.63	0.17	−0.50	0.18
Pollution	0.434	0.810	0.877	−0.95	0.18	−0.88	0.19	−0.95	0.18	−0.88	0.19
Health Risks	0.362	0.976	0.101	−2.11	0.21	−2.11	0.21	−1.41	0.35	−1.41	0.35
Natural Resource Managment	0.052	0.078	0.063	−0.79	0.19	−0.47	0.20	−1.87	0.54	−0.69	0.46
Ecoystem Based Management	0.691	0.303	0.800	−1.60	0.21	−1.29	0.21	−1.60	0.21	−1.29	0.21
Biological Conservation	0.025	0.247	0.009	−1.73	0.18	−1.73	0.18	−0.78	0.30	−0.78	0.30
Ecoystem Services	0.534	0.820	0.625	−1.14	0.15	−1.14	0.15	−0.97	0.31	−0.97	0.31
PhysioGeoChemistry	0.230	0.238	0.482	−2.20	0.26	−2.72	0.36	−2.20	0.26	−2.72	0.36
Economy	0.713	0.976	0.529	−1.91	0.19	−1.91	0.19	−2.22	0.47	−2.22	0.47
Environmental Law	0.106	0.077	0.077	−3.37	0.36	−3.37	0.36	−19.57	1505.86	−19.57	1505.86
Environmental Politics	0.457	0.241	0.314	−1.65	0.21	−1.29	0.21	−1.65	0.21	−1.29	0.21
Philosophy	0.050	0.022	0.098	−5.08	1.00	−3.03	0.42	−5.08	1.00	−3.03	0.42
Social science	0.263	0.672	0.140	−1.37	0.16	−1.37	0.16	−2.01	0.43	−2.01	0.43
Natural science	0.844	0.596	0.794	0.07	0.16	0.20	0.18	0.07	0.16	0.20	0.18
Humanities	0.720	0.687	0.283	−4.38	0.58	−4.38	0.58	−20.57	2482.75	−20.57	2482.75
Interdisciplinary research	0.253	0.395	0.240	−0.40	0.13	−0.40	0.13	−0.78	0.30	−0.78	0.30
other	0.555	0.328	0.386	−2.53	0.30	−2.12	0.28	−2.53	0.30	−2.12	0.28
To get data	0.000	0.000	0.000	2.92	0.12	3.65	0.13	2.27	0.24	2.71	0.29
To learn about stakeholders	0.440	0.929	0.333	1.02	0.15	1.02	0.15	0.69	0.30	0.69	0.30
To spread knowledge	0.008	0.735	0.003	0.28	0.13	0.28	0.13	1.29	0.34	1.29	0.34
Because funders demands it	0.029	0.004	0.890	−2.35	0.28	−4.17	0.71	−2.35	0.28	−4.17	0.71
Not interested in interaction	0.853	0.884	0.380	−4.78	0.71	−4.78	0.71	−20.57	2482.75	−20.57	2482.75
It increases quality of research	0.115	0.201	0.035	−0.19	0.13	−0.19	0.13	−0.88	0.31	−0.88	0.31
Lack time to interact	0.007	0.003	0.075	0.46	0.17	−0.30	0.19	0.46	0.17	−0.30	0.19
Lack funding to interact	0.447	0.306	0.496	−0.92	0.18	−0.64	0.20	−0.92	0.18	−0.64	0.20
Lack stakeholder contacts	0.666	0.951	0.301	−1.76	0.19	−1.76	0.19	−1.34	0.36	−1.34	0.36
Lack encouragement to interact	0.212	0.124	0.483	−1.49	0.21	−2.04	0.29	−1.49	0.21	−2.04	0.29
Lack know-how on interaction	0.523	0.144	0.836	−0.98	0.19	−1.42	0.24	−0.98	0.19	−1.42	0.24

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