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Simo Sarkki; Jari Niemela; Rob Tinch; Sybille van den Hove; Allan Watt; Juliette Young. 2013. Balancing credibility, relevance and legitimacy: A critical assessment of trade-offs in science-policy interfaces. Science & Public Policy. Published online: August 28, 2013. doi: 10.1093/scipol/sct046

The paper is available online at:
http://spp.oxfordjournals.org/content/41/2/194

Balancing credibility, relevance and legitimacy: A critical assessment of trade-offs in science-policy interfaces

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Abstract

To be effective in fostering strong connections between knowledge and policy action, science-policy interfaces, and the information they produce and exchange, should be credible, relevant and legitimate. Though this is widely accepted, there has been less emphasis on the problem of trade-offs between these attributes, and how the trade-offs manifest themselves in practice. Based on empirical material on biodiversity related science-policy interfaces, we identify and examine four major potential trade-offs: 1) Personal Time trade-off: interfacing vs. doing other activities; 2) Clarity-Complexity trade-off: simple messages vs. communicating uncertainty; 3) Speed-Quality trade-off: timely outputs vs. in-depth quality assessment; and 4) Push-Pull trade off: supply-driven vs. demand-driven research. Trade-offs are dynamic, vary through policy cycles, and evolve with changing contexts or internal dynamics between actors at the science-policy interface. We outline ways of easing the tensions inherent in trade-offs, but stress that appropriate solutions must be determined on a case by case basis.

Keywords: Science-policy interface; trade-off; biodiversity, credibility, relevance, saliency, legitimacy.

1. Introduction

While it is generally agreed that there is an urgent need to bridge the gap between science and policy to enhance the use of scientific knowledge as a basis for decision-making (Brundtland 1997; Turnhout et al. 2008), questions remain over how this can best be achieved.

Knowledge transfer between science and policy-making and practice was once thought of as a linear one-way process between distinct domains, but this model is being replaced by the notion that boundaries between science and policy (be it public policy-making or more broadly decisions-making in the public and/or private spheres at all scales) are blurred with complex two-way relationships (Engels 2005; Jasanoff 1994; Lentsch & Weingart 2011; Lövbrand 2011; Nowotny et al. 2001; Pielke 2007; van den Hove 2007; van Kerkhoff & Lebel 2006). Science-policy interfaces (SPI) exist within, and seek to manage, this fuzzy boundary area. SPIs can best be thought of as social processes which encompass relations between scientists and other actors in the policy process, and which allow for exchanges, co-evolution, and joint construction of knowledge with the aim of enriching decision-making and/or research (adapted from van den Hove 2007: 807). They can range from large and highly formalized institutions to informal discussions between two individuals.

Complex interactions at the science-policy interface are poorly understood, but the framework proposed by Cash et al. (2003) suggests that three key attributes, credibility, relevance and legitimacy (CRELE), are important determinants of the effectiveness of improving the use of science in decision-making. SPIs can be considered ‘effective’ when they facilitate interaction processes between science, policy and stakeholders in such a way as to meet the needs and expectations of participants, foster the integration of science in decision-making, and generally exert influence on both SPI participants and other target audiences. Central to effectiveness is the ability of SPIs to influence the behaviour of intended audiences, through enhancing their knowledge of the consequences of their decisions. The CRELE framework suggests that SPIs can enhance their capacity to influence behaviours by developing their credibility, relevance and legitimacy (e.g. Koetz et al. 2012; Weichselgartner & Kasperson 2010).

Credibility refers to the (perceived) quality, validity and scientific adequacy of the knowledge exchanged at the interface. It includes credibility both of the knowledge production processes and of the knowledge holders. *Relevance* (or *saliency*) refers to the responsiveness of the SPI to policy and societal needs. *Legitimacy* refers to the (perceived) fairness and balance of the SPI processes, including inclusiveness of other stakeholders, transparency, fairness in handling of diverging values, beliefs, and interests (Cash et al. 2003; Farrell & Jäger 2006).

The CRELE attributes have been adopted in the policy sphere, for example by the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) (Busan outcome 2010). However, potential trade-offs and synergies between these attributes are acknowledged (Cash et al. 2003; Girod et al. 2009; White et al. 2010). Managing these trade-offs is challenging, partly because credibility, relevance and legitimacy are perceived differently by different actors (Cash et al 2003), and also because the appropriate balance varies according to contextual factors such as the stage of the policy cycle (Lövbrand 2011; Vogel et al. 2007), policy makers' and other target audiences' values, belief systems or cultures (Turnhout et al. 2008), and the 'type' of SPI (e.g. in terms of geographical scale, closeness to policy or science domains) (Engels 2005).

The notion of trade-offs between credibility, relevance and legitimacy is heuristically useful and provides some guidance in the concrete management and design choices for SPIs, but remains somewhat abstract. In order to move from abstract notions to practice we need to understand how different features of SPIs contribute to building the CRELE attributes. However, there are very few studies addressing the practical meaning of the abstract trade-offs between credibility, relevance and legitimacy. Girod et al. (2009) examined the evolution of the Intergovernmental Panel on Climate Change (IPCC) scenarios and found that the IPCC scenario development prioritised exploration and deliberation of a wide range of alternative and conflicting views, in order to enhance legitimacy. This resulted in a large number of complex scenario storylines. Girod et al. (2009) go on to argue that a smaller number of scenarios, with simpler structure and content, would increase both relevance and credibility, at the cost of some loss of legitimacy through exclusion of less typical viewpoints. White et al. (2010) found that close links between science and policy concerns ensured high relevance but led to some stakeholders being dissatisfied with the credibility and legitimacy of a decision support tool for water resources management.

There is therefore a need for improved guidance on the identification of trade-offs, on anticipating them in the design of science-policy interfaces and on ways to address them when they arise. The aim of this paper is to start filling this academic and policy gap by identifying how the abstract trade-offs and synergies between CRELE attributes are manifested in practice, how they impact on the design, operation and effectiveness of science-policy interfaces, and how they can be overcome.

Below, we present an analysis of four key trade-offs identified through interviews and workshops. We draw on empirical results and literature to address each trade-off in turn, starting with a description the trade-off in question, providing empirical examples, examining how context-specific features influence the trade-off, and discussing some possible ways of addressing the trade-off. We conclude by considering some general features of the trade-offs considered, and associated research recommendations. This work, and future research in this field, can help individuals and groups involved in science-policy interfaces to make informed choices about structures and processes for more effective science-policy interfaces.

2. Identifying four practical trade-offs between credibility, legitimacy and relevance

The empirical evidence collected for this paper is based on two workshops and eight interviews. The workshop participants and interviewees were scientists and policy makers with extensive involvement in biodiversity related science-policy interfaces (Table 1). Furthermore, several scientists included in the SPIRAL (2013) project with wide ranging experiences of science-policy interfaces contributed to the workshop discussions. The SPIs discussed included well-known global interfaces, such as the Millennium Ecosystem Assessment (MA), the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES), The Economics of Ecosystems and Biodiversity (TEEB), the Global Environmental Outlook (GEO), the Global Biodiversity Outlook (GBO), as well as various smaller scale and/or more narrowly-focused biodiversity-related SPIs. These cases revealed some important ways in which credibility, relevance and legitimacy could both influence and be dynamically changed through science-policy interactions, resulting in practical tensions and trade-offs. We acknowledge that the SPIs examined here are specific kinds of interface focused mainly on assessments and initiatives that aim to bridge the science-policy boundary. We recognize that these cases do not focus as much on the interactions between scientific advisors and policymakers (see Ascher et al. 2010; Jasanoff 1994) or on the different roles scientific advisors can take throughout the policy cycle (Campbell Keller 2009). However, the trade-offs identified and discussed here may be highly relevant for other kinds of science-policy interactions by identifying general tensions and ways to manage these tensions.

Table 1. Empirical material

Material based on	Timing	Number of participants or interviewees	Number of scientists	Number of policy makers	Female / Male
First workshop	March 2011	11	5	6	5/6
Interviews	September 2011	8	7	1	2/6
Second workshop	December 2011	11	7	4	6/5

Both workshops used a story-telling method to encourage participants to share their experiences of science-policy interfaces. Story-telling is an emerging method for engaging participants more strongly with research, encouraging them to share experiences with others in a semi-formalised way and to reflect on their experiences from the point of view of questions posed by the researchers and other participants (see Gubrium 2009; Labonte et al. 1999). The participants were asked to structure their stories around *features* explaining the *success or failure* of the SPI to influence the behaviour of its target audiences. Successes and failures were related to a variety of features: for example procedural issues that enhanced or hindered communication, institutional arrangements that enhanced or reduced credibility or legitimacy, and factors influencing the accessibility and relevance of SPI outputs for their target audiences. An overview of features explaining success and failure to influence identified through our workshops and interviews is given in Table 2. Participants were asked to link these explanatory features to CRELE *attributes*: thus the explanatory features are considered as practical, observable characteristics of SPIs that together determine the more abstract constructs of credibility, relevance and legitimacy, which in turn provide a means of understanding and explaining the *influence* of SPIs in particular contexts.

Written evidence from the workshops and interview transcriptions was clustered to form categories to identify important features in the design of science-policy interfaces, in particular features that enhance or hinder a SPI's ability to promote societal change by influencing the behaviour of policy makers, scientists and other target groups. Based on discussions at the first workshop we identified 44 such features, and tested this set of features in interviews. Interviewees suggested consolidating the list of 44 features, and gave additional empirical examples linking SPI features to the influence on target audiences. We then clustered the features from the interviews and workshop 1 under more general categories. In addition to a story-telling session, the second workshop focused on reviewing and refining the list of features and developing a related set of lessons learned. Combining all the results allowed us to identify a final set of 14 success/failure features (Table 2). The success/failure features and lessons learned can be interpreted in terms of their impacts on credibility, relevance and legitimacy, and this analysis leads to some recommendations for SPI design (see Sarkki et al. 2012a, b). The recommendations are context-specific, because the relative importance and impact of different SPI features depends on the requirements and characteristics of specific policy contexts. This means that trade-offs between SPI features need to be balanced differently depending on contextual factors.

Table 2. Features explaining SPIs' influence on target audiences (Summary from Sarkki et al. 2012a)

Features	**What to assess**
Independence	Freedom from external control, neutrality or bias in position, range of membership
Participation	Range of relevant expertise and interests included; competence of participants; openness to new participants
Resources	Financial resources, human resources (e.g. leadership, champions, ambassadors, translators), networks, time
Vision	Clarity, scope and transparency of the vision and objectives of SPI
Drivers	Demand-pull from policy, mandates, supply-driven promotion of research, emerging issues
Horizon scanning	Procedures to anticipate science and policy developments
Continuity	Continuity of SPI work on the same issues; continuity of personnel; iterative processes
Conflict management	Strategies such as third party facilitation; allowing sufficient time for compromise
Trust building	Possibilities to participate in discussions, clear procedures, opportunities for informal discussions; transparency about processes and products
Capacity building	Helping policy makers to understand science and scientists to understand policy makers; building capacities for further SPI work
Adaptability	Responsiveness to changing contexts; flexibility to change
Relevant outputs	Timely in respect to policy needs, accessible, comprehensive; efficient dissemination
Quality assessment	Processes to ensure quality, comprehensiveness, transparency, robustness, and management of uncertainty
Translation	Efforts to convey messages across different domains and individuals, and making the message relevant for various audiences

To identify trade-offs we systematically searched for direct statements from interviews and workshop participants identifying tensions, contradictions or trade-offs between two incompatible, but important issues. We also searched for trade-offs by contrasting the lessons learned under each feature and found that there were both internal trade-offs within single features, and also trade-offs across different features. As a result we found evidence for several trade-offs: we then built more general categories from these trade-offs, and prioritised them, to identify four key trade-offs to be examined in this paper. Table 3 summarises the trade-offs identified, and the general categories analysed.

Table 3. List of trade-offs identified from workshops and interviews.

General trade-off category examined in this paper	**Specific examples of trade-offs from our material**
Personal Time trade-off: *Interfacing vs. focus on main role*	To 'waste' time in science-policy work vs. to pursue career by publishing peer-reviewed research (scientists) or carry out high-profile policy work (policy makers).
Clarity-Complexity trade-off: *Simple, strong, clear messages (relevance) vs. thorough treatment of uncertainties and systemic dimensions (credibility, legitimacy).*	Pictures, figures and maps seen as efficient translation tools. However, they compress and simplify message and often omit uncertainties.
	Communicating uncertainty and complexity is important, but media and vested interests might not play along or even use it as a means to discredit the science (e.g. Michaels 2008; Oreskes & Conway 2010), instead focusing selectively on one view. SPI can lose control of the message.
	Trade-off between strong, clear messages regarding key variables, and more nuanced reporting of full range of uncertain outcomes – more credible and legitimate but may reduce impact and relevance.
	Choosing strategy between issue advocacy and honest broker (Pielke 2007): lobbying with clear messages may be more effective / relevant in some instances, while honest brokerage opening up uncertainties and various valid representations of an issue and various options to address it probably increases credibility.
	Consensus building procedures may give outputs that are hard to revise or update, which challenges continuous acknowledgement of complexities and divergent views (Stirling 2010).
Speed-Quality Trade-off: *Timely and rapid responses to policy needs (relevance) vs. time-consuming quality assessment (credibility) and/or consensus building (legitimacy).*	Covering all paradigms may bog process down in fundamental disagreements: risks to timeliness and clarity.
	Patience can be a virtue: though timeliness is important, publishing premature results can decrease trust, lead to unnecessary conflict and damage credibility.
	Enhancing legitimacy by including full range of interests and

	perspectives could decrease relevance and credibility if expertise is compromised or procedures become too slow.
Push-Pull trade-off: *Following strongly policy demand (relevance) vs. more supply-oriented research strategies to enable the identification of emerging issues or the development of innovative solutions (credibility, legitimacy).*	Danger of 'lock-in' if SPIs become too strongly focused in a specific paradigm or policy: may end up producing knowledge only for immediate policy needs, missing emerging issues and losing credibility and relevance in the long run –(EEA 2013).
	SPIs that are too supply-led may produce knowledge on interesting new issues without ever achieving policy relevance or answering policy needs.
	Right to veto and consensus base can enhance legitimacy and buy-in but allow vested interests to hamper progress. Consensus is needed to produce strong mandate from governments, and if there is no consensus mandate suffers. On the other hand, non-consensus would allow explorations of more divergent viewpoints that could build legitimacy for the assessment.
Other trade-offs not addressed by this paper	Challenges related to democratization of science and inclusion of various other types of knowledge, without 'watering down' scientific evidence.
	Increasing trust in small high-level group (e.g. Chatham House Rules) may create more effective coordination but risks reducing trust and transparency for wider group.

After identifying these trade-offs, we classified supporting and contradictory evidence from our data for each aspect of the trade-off. We were particularly interested in their significance in terms of the SPIs' ability to influence their target audiences. We also considered both aspects of these trade-offs in the context of their credibility, relevance and legitimacy, and explored ways of easing the trade-offs. The next section explores how the four trade-offs were represented in the empirical material and discusses how these trade-offs link to literature. A synthesis is provided in Figure 1.

3. Exploring the four trade-offs

3.1. Personal Time trade-off: Interfacing vs. doing other activities

According to our results, the personal time trade-offs faced by the policy makers and scientists who could participate in SPI work has important impacts on credibility, relevance and legitimacy. Participation of well-respected scientists enhances the overall credibility of the interface, and broad participation makes it more likely the interface is able to produce more scientifically sound and credible results, and enhances legitimacy where divergent perspectives are included. Participation of policy makers increases relevance by enhancing linkage between the knowledge producers and users. As stressed by one workshop participant: *"there is no best practice, it comes from best people".* In this regard ensuring that key individuals are motivated to participate in SPI activities is essential,. Achieving sufficient and maintained levels of participation and buy-in are vital for any SPI, so an understanding of the personal trade-offs and ways to address them is important.

SPIs are hindered by the lack of incentives for scientists to take part in policy-related work. This is because research institutions tend to reward their staff for producing academic publications (Moll & Zander 2006) rather than rewarding applied policy related work (Phelan 2000). This suggests that there is a structural tension that leads to personal trade-off regarding scientists' motivations to participate in SPIs (see Cash et al. 2003). It was also widely agreed in the workshops and interviews that there are few incentives for scientists to engage in SPIs apart from personal motivations, such as a wish to contribute to solving societal and environmental problems. Scientists get credit from peer reviewed publications, but not from participating in SPIs. Thus SPI work can represent a time cost for scientists, with no clear benefits. An example was given by one of the interviewees: '*It was a 2 year process the UK NEA [National Ecosystem Assessment] and by the end of 13 months people had put so much into it, and they could not keep up the volunteer work they* *had invested in it, they just dissolved. It was like survival of the fittest at the end. SPIs should not depend on the energy of individuals.'*

Our results also suggest that policy makers often lack incentives to participate in SPIs, a fact that is poorly studied in the science-policy literature, which often focuses on scientists' motivations. Problems with the incentives and motivations of policy makers to take part in SPIs were identified in interviews and workshops. Firstly, long discussions about science are for many policy makers quite unusual and considered as time away from 'proper work'. This creates difficulties for policy makers, e.g. to get authorization to travel to science-policy meetings. Secondly, policy makers may feel that these kinds of activities create a negative image for them, particularly in times of austerity. Thirdly, the topics addressed by the science-policy meetings may be too narrow and specific for policy makers, or address the issue at scales different than would be interesting for policy makers. Fourthly, to proceed with their careers policy makers are often required to demonstrate experience across a wide range of issues,, and this creates fast turnover in policy positions and connections to SPIs. As stressed by one of the interviewed scientists this may result in situations where *"you loose institutional memory, and social learning aspect".*

However, our evidence suggests that there are ways to address the personal time trade-off by increasing scientists' and policy makers' motivations to participate. Firstly, academic attitudes may be changing, and it was noted in an interview that some young scientists have started to put SPI work in their CVs. *'In the old days it was a negative, because it took time away from your work what you do here, but now it is actually an honour to be selected by an international community to do this. And that has been a big change.'* There is a link here with evolving research funding mechanisms and increasing emphasis on demonstrating policy relevance and dissemination. This highlights a possible change in scientific culture to value applied, policy-relevant work. That scientists are chosen as SPI participants may be seen a sign of recognition from their peers, a valuable aspect in terms of career development. At the institutional level, participation of scientists can be encouraged by rewarding scientists' SPI activities through formal recognition within performance assessments and career progression, and through attaching dissemination, outreach and interfacing conditions to research funding.

Secondly, Cash & Moser (2000) noted the importance of matching scales when integrating science and policy: SPIs need to increase interaction between scientists and policy makers to ensure that the scales addressed by scientists match those considered important by policy makers (e.g. Paloniemi et al. 2012). Our results suggest that matching the scales is a motivation for policy makers to acknowledge and use the knowledge provided by scientists and SPIs.

Thirdly, scientists can be motivated by policy demand: the interest of a high level policy maker in one's work can be highly satisfying. Furthermore, incentives are created if scientists feel that their efforts are relevant and worthwhile in contributing to solving important societal problems. Similarly, policy makers can consider it rewarding to be more knowledgeable about important scientific issues, which contribute to their capacity to address real world problems in their work. Added value for policy makers can be enhanced by ensuring that the SPIs address areas of importance for policy in a timely way, that the frameworks used are accessible for policy makers, and that the problem framing fits their policy interests. SPIs can also serve as kind of reality check for policy makers on knowing what the issues of importance are from the science community point of view, and for scientists to know the knowledge needs from the policy side.

3.2 Clarity-Complexity trade-off: Simple messages vs. Communicating uncertainty

In this section we explore the trade-off between presenting simple, strong and clear messages, hence enhancing relevance, and thorough treatment of uncertainties and ignorance and diverging values, hence fostering credibility and legitimacy. Transparency and full reporting of the limitations and uncertainties of scientific findings is an important aspect enhancing credibility of scientific knowledge (Stirling 2010; Wilson 2009) and is also important for legitimacy, ensuring that all options are explored and fairly treated. However, if uncertainties and complexity are communicated credibly, then relevance for policy-makers may decrease as knowledge may be in a more complex form that is harder for policy makers to understand and/or to integrated directly into policy work (Vogel et al. 2007). In the worst case, policy makers may choose to ignore the information received (Hall and Paradice 2005). This may be because policy makers may seek certainty and deterministic results from scientists, which are easier to use (Bradshaw & Borchers 2000), or in some cases search for knowledge that will support their own pre-determined positions (Collingridge & Reeve 1986). This view was held also by some workshop participants: *'politicians are not interested in facts, but in facts that support their views'*. Where this leads to pressure on SPIs to make oversimplifications, this can in turn reduce scientific credibility and legitimacy, and increase the risk of findings being contested (Nowotny 2003), and of discouraging future participation by scientists who perceive this as a misuse of evidence.

It was widely agreed among our workshop participants that even where scientists are doing excellent research, they often fail to present the results in a form that is easily understandable by policy makers and stakeholders: *'the content is there, and the work is done, but the package is completely wrong. How they sell it, how they write it: [it should be] not 20 pages but one page!'* It was emphasized that policy briefs, pictures, maps and figures may be particularly efficient translation tools to simplify messages for policy. The Scientific Committee on Antarctic Research (SCAR) was cited as an example where important resources were used to communicate that new marine management rules should be implemented in the Antarctic. This resulted in policy makers acknowledging the work, but with minimal further action. In the end, a decision was taken based on *'a nice picture from the sea bottom':* the picture was an important translation tool in making dry arguments 'real' for policy makers. Communicating about complexities and diverse views may also cause difficulties when dealing with the media. According to an interviewee *'If you have clear* *message, then [work with media] is rather straightforward, but working with conflicts you have to be really careful because [the media] will pick just one part of it.'*

Policy demand for clear, simplified and strong messages was also highlighted in interviews relating to TEEB and the Global Biodiversity Outlook 3 (GBO 3). In TEEB, policy makers wanted numerical results in time for the 2009 Copenhagen Conference of the Parties of the United Nations Framework Convention on Climate Change (UNFCCC): *'[There] was pressure to come up very quickly with some results. And also to meet expectations of policy makers, they expected us to produce numbers and figures, numbers in Euros. It was sometimes hard to really get science behind what policy makers expected us to deliver. On the other hand, it helped us to bring very relevant messages.'* This created incentives for scientists to adapt their messages to suit policy actors better, even though insistence on quantification often produces an *'aura of formality and objectivity, and a precision that is often not justified'* (Wilson 2009: 82). In addition, the post-normal view on science stresses that not all uncertainties can be quantified: it may actually be more useful to explore uncertainties in full, rather than focusing effort on quantifying uncertainty only in the part of the knowledge that is reliably quantifiable (Petersen et al. 2011).

A major problem with tools that compress and simplify messages is that they are often unable to account for and communicate uncertainties. For instance, a scientist engaged in the GBO 3 process reported that uncertainties linked to scenarios on extinction rates in GBO 3 were omitted from the summary report, even though scientists thought that these uncertainties were among their key findings. The interviewee felt that policy makers wanted knowledge of tipping points and strong messages from GBO 3, and that science was being made less credible as a result. However, communication of clear tipping points made the issues more concrete for delegates and the Subsidiary Body on Scientific, Technical and Technological Advice (SBSSTA) of the Convention on Biological Diversity (CBD).

While there are recommendations in the literature for scientists to 'keep the issue complex' (Stirling 2010), it is commonly thought that policy makers are less happy to receive information that is complex and uncertain – as in the TEEB and GBO 3 examples, where policy makers wanted strong results that did not seem to leave room for uncertainties. However, policy makers can be comfortable with uncertainties as noted by an interviewee in relation to the Biodiversity Expert Group, a science-policy interface set up by the Directorate General for Environment of the European Commission. Furthermore, an interviewed policy maker stressed that '*the naïve view that policy makers can't deal with ambiguity, can't deal with fuzzy things is completely wrong'.* Indeed, the interviewee argued that it is more difficult for policy makers when scientific results were presented as an absolute truth. This results in a kind of *'take it or leave it'* situation, where policy makers have no choice but to work according to the specific scientific advice or to ignore it, with a strong chance that such 'absolute truths' are more often than not ignored rather than taken up by policy makers. The interviewee involved in GBO 3 noted that *'they [policy actors] were comfortable with uncertainty as long as it did not put them in an uncomfortable situation compared to what they had said before'.*

Where policy makers prefer uncertainties, this can be a consequence of them wanting to choose between decisions with all available information at hand, but it can also be because they believe it allows them to pick the evidence that best supports the political agenda. Policy makers may attempt to hide their decisions behind an aura of scientific objectivity. For example, while scientists in fisheries management have provided a range of options, policy makers have often chosen the most optimistic option – or even gone beyond this – which has led to the serious depletion of many fish stocks (see Wilson 2009; McGlade and van den Hove 2013). This in turn has reduced credibility of associated SPIs and fisheries science. Thus, dynamic feedback can be observed: SPIs give advice, which is ignored or misused resulting in bad policy results, and blame may even be passed from policy to science. Furthermore, scientists may also present the uncertainties in a light that supports a certain management option, especially when they are pushing an agenda and trying to compete with an opposing party of scientists pushing an alternative agenda (Sarkki and Karjalainen 2012). So presenting clear policy advice may increase relevance, but at the same time the narrower scope increases the risk of critique from other perspectives, may compromise legitimacy and credibility, and involves the risk of policy makers becoming politically tied or otherwise locked-in to positions based on early statements, or of rejecting the evidence altogether.

Policy makers' preferences are likely to be context dependent: policy makers may tend to prefer communication of uncertainties and complexity in the early phases of the policy cycle (e.g. problem identification and definition) but may require more definitive and clear advice in later phases in the policy cycle (e.g. implementation, monitoring); (see also Lövbrand 2011). Where the SPI activity is less focused on a specific policy need, and more related to seeking an audience and a mandate for new concepts, early clarity may be very useful. In the TEEB case, greater caution about scientific messages and communication of uncertainties was made possible later in the project, because successful communication of key messages in the early stages led to scientists gaining a stronger position – becoming more credible and more relevant in the eyes of policy makers – thanks to their initial policy-focused results.

3.3 Speed-Quality Trade-off: Timely outputs vs. in-depth quality assessment

A third trade-off occurs between the ability to provide rapid responses to policy needs (enhancing relevance), and time-consuming quality assessment (fostering credibility) and consensus building processes between plural perspectives (promoting legitimacy).

Enhancing connectivity between science and policy requires that scientific outputs (e.g. reports) are made available within a timeframe appropriate to the policy-making process (Lentsch and Weingart 2011; Miles et al. 2006). This requires an understanding of the policy cycles and of relevant policy actors and processes (Haas 2004), a more general appreciation of policy makers' needs, and the ability to communicate messages in good time (Guldin 2003). Early communication may be a challenge for scientists who are used to time-consuming peer review processes aimed at ensuring credibility (Blockstein 2002). Furthermore, SPIs may aim to produce legitimised knowledge through extended peer review (Funtowicz & Ravetz 1993; Nowotny et al. 2001). Peer and extended peer review processes, and exploration of various data, material and stakeholders' perspectives, increase credibility and legitimacy, but these quality control processes reduce the ability to provide timely advice and rapid responses to policy needs. On the other hand, credibility and legitimacy may suffer if SPIs prioritise relevance through rapid responses to policy issues, bypassing time-consuming participation and quality control measures.

This trade-off was widely discussed in our workshops and interviews. One policy maker noted that '*we cannot wait for three years that you come up with your mid-term research study and peer reviewed papers'.* On the other hand, the importance of quality assessment is apparent, a most notable recent example being the criticisms against the IPCC. According to workshop participants, the inclusion in the 2007 IPCC WGII report of the unjustified projection that Himalayan glaciers could disappear by 2035 was an opportunity for opponents of the IPCC to emphasise the lack of sufficient peer review. The opponents were quick to pick up on the lack of an iterative process verifying knowledge that would have increased credibility. Another participant noted that the International Council for the Exploration of the Seas (ICES) has a well-defined quality assessment process, which was widely seen to increase credibility of the produced knowledge. Participants discussed also the design of the IPBES, noting that extended stakeholder review and additional ways to verify quality of knowledge, beyond scientific peer review, will be needed in order to integrate different types of knowledge.

Timely advice may not only conflict with quality assessment processes, but also with exploring various views, wide participation and consensus building, all of which were highlighted in the workshops and interviews as important factors explaining SPIs' influence on their target audiences. It was noted in the workshops that right to veto and consensus processes can enhance legitimacy and buy-in (as in the case of IPCC assessments' summaries for policy makers for instance), but can also allow vested interests to hamper progress, so that credibility and relevance may be compromised. In contrast, non-consensus processes can allow explorations of more divergent view points, potentially building legitimacy for the SPI, but decreasing relevance, timeliness and clarity, and compromising credibility if ill-informed or vested interests are pushed on to the agenda. So the relationship between consensus / non-consensus processes and legitimacy is ambiguous, but overall it seems that providing rapid advice is likely to conflict with legitimacy. We recognize that a more thorough exploration of approaches in terms of compromises (van den Hove 2006) is needed but it is beyond the scope of this paper.

It is also interesting that exploring the full range of views seems to be in synergy with quality assessment (e.g. extended peer review), and with communication of uncertainties and complexity, if heterogeneous viewpoints stem from underlying uncertainties or conflicting information (see van der Sluijs 2006). There may be again a trade-off with timely advice as exploring a range of views takes time. So there is a connection between the clarity-complexity trade-off and the speed-quality trade off. There is an important difference, however, in that the speed-quality trade-off relates to how uncertainty is dealt with within SPI processes, while the clarity-complexity trade-off relates to the question of how uncertainty is reported and presented in SPI outputs.

Our results showed that there are some ways to ease the trade-off between timely advice and thorough quality assessment procedures. Firstly, timely submissions of scientific advice can be ensured by being aware of key stages in the policy cycles of relevant policy actors (e.g. important meetings, decision points) (Haas 2004). The tension can also be eased through early interactions between scientists and policy makers to communicate policy deadlines to scientists. This is important as policy inaction will often have real and significant consequences, and in order to make decisions quickly, policy makers have to work with the best available information at a given point in time. Secondly, there can be cases where by the time the answer is there, the question is no longer politically relevant. Even though not all political changes can be planned sufficiently in advance, it can be possible for a SPI to scan horizons, plan for flexibility, and endeavour to play a role in shaping the next generation of political questions. Thirdly, informal interactions could help: workshop participants emphasised the usefulness for policy makers to know 'who to call' to get fast, reliable advice. Furthermore, it was suggested that presenting early or mid-term results to policy makers should be encouraged. This could alleviate the problem of timely outputs, but requires good relationships between policy makers and scientists. In addition, the risk of policy makers being locked-in to positions based on early, maybe weaker, evidence should be considered.

3.4 Push-Pull trade-off: Supply vs. demand-driven research

There is a trade-off between supply and demand driven research. In general terms supply driven strategies foster credibility through independence while demand driven strategies enhance relevance.

Policy demand was considered as important factor facilitating SPIs' influence on policy by workshop participants and interviewees. Interviewees involved in large scale assessments and SPIs noted the importance of the SPI having a political mandate to minimise the likelihood of scientific results being ignored by policy makers. An interviewee stated that in the IPCC model, assessments are carried out at the request of governments, which then need to acknowledge the assessments formally. This is different from the GBO 3 case, where there was no mandate. This led one interviewee to conclude that when the GBO 3 assessment was put on the table governmental representatives could just ignore it: *'they did not ask for it and they did not get to influence what is in it'*. This was compared by the interviewee to the failure of Global Biodiversity Assessment

(GBA: a large scale biodiversity assessment carried out in the mid 1990s by some of the world's most renowned biodiversity scientists) to produce policy impact (see also Watson 2005). The GBA policy failure was also taken up by other interviewees and workshop participants to emphasise the need for close policy connections and mandate in order for SPIs to have policy impact. However, GBA was considered by an interviewee as learning experience for the global biodiversity community. In a dynamic sense, the 'failure' of the GBA to influence policy could be re-cast as a success in terms of providing the intellectual background as well as views of how to better organize subsequent processes such as the MA or IPBES. According to the interviewee this is apparent in the increasing structural connections and governmental mandates of successive biodiversity assessments: the GBA was not an intergovernmental process, the MA was also not intergovernmental yet it was linked to a series of international treaties including the CBD, and the IPBES is intergovernmental and organized under the auspices of the UN, making the connection to governments even stronger (see also Leemans 2008; Watson 2005).

Informal demand can, however, also have advantages: it is easier for policy makers to distance themselves from outcomes they dislike if there is no formal demand, and this could make the process more flexible and more open to exploring riskier areas. Furthermore, formal mandates are likely to mean tighter political control of the processes and outcomes, as the current negotiations over IPBES illustrate.

The workshop discussions were very much focused on how scientists could interact with policy makers and take account of specific demands for knowledge to increase relevance, with less attention paid to how supply-led strategies could lead to producing policy relevant knowledge. This bias may also be reflected in the current literature on SPIs. Many authors state that SPIs should seek mandates (e.g. Lentsch and Weingart 2011), adapt to the requirements posed by different phases of the policy cycle (Lövbrand 2011; McNie 2007; Vogel et al. 2007) or adapt to the diverging types of policy problems (Engels 2005; Turnhout et al. 2008), while the importance of supply is less of a concern. However, Jacob (2006) and Wynne (1982) argue that relying too much on policy demand may lead to narrowing the scope of the scientific agenda aiming at influencing policy and exposing knowledge to manipulation by certain interests. Furthermore, it was stressed in the workshops that close connection to policy agenda may lead to an SPI being considered to serve vested interests and as such ignored in some negotiation forums.

Participants felt it important that not all research be focused on immediate policy needs: independent and curiosity-driven research, generating evidence on emerging issues and potential solutions and looking ahead of the immediate political game were highlighted as essential. SPIs can play a role in shaping the next generation of policy priorities, for example through identification of emerging issues and early warnings. The example of ecosystem services was cited in the workshop: the synthesis of the Millennium Ecosystem Assessment (2005) has now been taken up strongly by policy actors and stakeholders, and this has led to a striking increase in scientific research in the field. When SPIs have been able to create demand for certain types of knowledge (e.g. regarding ecosystem services) by knowledge brokering, this demand can create a virtuous cycle between supply and demand of knowledge within the prevailing paradigm. But this increasing focus on a specific paradigm may turn against independent and curiosity-driven research, narrowing the scope of science-policy discourse and ultimately the resources for other approaches within science.

While there is some truth in this, scientists have also been quite critical towards the ecosystem service concept. For example, an interviewee wondered whether current efforts to assign monetary values to ecosystem services might be masking some other values that could not be expressed in monetary terms, and if the focus on flow of services could be masking fundamental dependencies of societies on nature. There are currently two European research projects (BESAFE 2013; BIOMOT 2013) specifically exploring the usefulness and limitations of different ways of arguing the case for biodiversity conservation, as a direct response to the increasing dominance of ecosystem services frameworks. So in fact the case of ecosystem services can be considered as a good example of how new concepts emerge and are debated critically.

Another dynamic aspect comes from the fact that policy communities are heterogeneous. This is especially important in environmental policy, and in particular biodiversity policy. Policy demand within an environment ministry, or in the nature conservation sector, does not necessarily mean that there is policy demand in all the sectors that impact biodiversity and healthy ecosystems. The vital importance of 'mainstreaming' to achieve biodiversity conservation targets is recognised in the Aichi 2020 biodiversity targets, Strategic Goal A: *'Address the underlying causes of biodiversity loss by mainstreaming biodiversity across government and society'*. (CBD Aichi Biodiversity targets 2012). The multiple policy competences and internal debates within the policy sphere make the notion of policy demand far more subtle and complex than a simple 'science' vs. 'policy' framework allows for. Acknowledgement of these dynamics is needed to remain sensitive to possible biases and limitations of produced knowledge.

An important distinction was made in the workshops between policy relevant knowledge and policy demand: knowledge may be relevant even if it is not being demanded, and supply of relevant knowledge may create demand. Policy demand and policy relevance should be considered distinct issues: if they are equated, there is a risk that policy demand becomes easily over-emphasised at the cost of the supply side, and this can neglect the SPIs' role as important knowledge brokers or communicators of relevant emerging issues or issues that some people would prefer to ignore. Policy relevance can be achieved by both strategies: supply- or demand-driven science. Demand-driven strategies may enhance immediate policy relevance, but supply-driven strategies may achieve policy relevance over longer time horizons, and may give greater opportunities to enhance credibility and legitimacy, if appropriate processes are established for fostering these characteristics.

3.5 Summarizing the trade-offs

Figure 1 summarizes the trade-offs identified above and presents some of the characteristics potentially enhancing CRELE attributes, based on our empirical material. These characteristics may be in synergy with each other, or in trade-off.

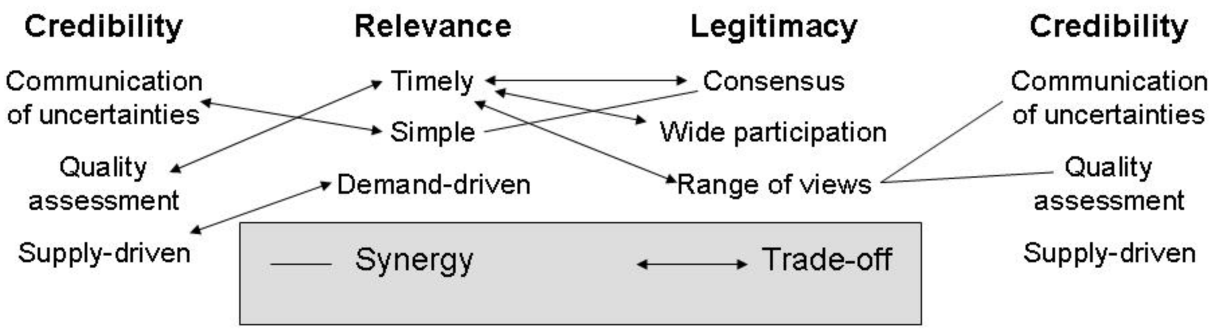

Figure 1. Trade-offs and synergies between credibility, relevance and legitimacy, and some key features.

4. Discussion and conclusion

Trade-offs can be thought of as unchanging (context-independent), unavoidable (there are no win-win solutions) and / or one-sided (there is a 'right' solution). Our research suggests that these views are often simplistic. General tensions or trade-offs exist but vary significantly from one case to another. Moreover, trade-offs are not static, but highly dynamic in relation to changing contexts and the actions taken to deal with trade-offs. There are ways to ease the tensions, but appropriate solutions can rarely be generalised and must be determined on a case by case basis. Yet, there is often a tendency to consider one option as generally 'better' when a trade-off is identified. For example, communication of uncertainties tend to be considered 'better' than simplified messages and demand-led SPIs more effective than supply-led ones. We argue that the more appropriate option is almost always context specific. If one option, one way to deal with a trade-off, becomes generally preferred over the other, there is a danger that the benefits of the under-valued choice are lost, resulting in a SPI less able to operate effectively in different contexts, or through different stages of a policy cycle.

It can therefore be useful to identify which trade-offs are *fundamental* (i.e. they cannot be resolved under any circumstance), *resource dependent* (can be solved with additional resources), *context specific* (acute only in some contexts) or *dynamic* (changing, for example, according to an evolving context, or displaying path-dependency where initial choices shape or limit future options). We briefly discuss these issues below.

As we have illustrated, most trade-offs are not fundamental. For example, in the speed vs. quality trade-off, timeliness of policy advice by scientists in relation to the policy agenda seems to be an absolute necessity. If the advice is late, decisions are taken without it. If it is early, it may be forgotten by the time policy-makers focus on the issue. Yet, the production of quality knowledge takes time, both for the research itself and for the quality assessment processes. Thus, this trade-off seems to be fundamental. However, SPIs can soften the trade-off by being aware of, and anticipating, policy deadlines well in advance. Though SPIs cannot anticipate every step and development in the policy arena, it is possible for a SPI to scan horizons, plan for flexibility in addressing policy deadlines, and even play a role in shaping the next generation of questions addressed by policy. This requires SPIs to encompass a longer term perspective and conceive of science-policy interactions as dynamic processes instead of punctual interventions where the speed vs. quality trade-off seems unresolvable.

Many successful resolutions of trade-offs seem to be context dependent, meaning that the context of a situation determines how the trade-off is managed. The social status of scientists and SPIs (which may vary in time but also depending on the cultural context), the stage in the policy cycle, and degree of problem structuration are three particularly important contextual factors which will influence how the trade-offs can be resolved or at least eased. For instance, it was evident during the story-telling sessions describing SPIs in different countries that the social status and thus also ability of SPIs to influence policy varied across countries (see also Renn 1995; Engels 2005), and could also change through time. It was also noted during the workshops that in some countries science is often perceived as being unable to produce 'the right knowledge at the right time' for policy. In such situations, measures to increase the relevance of science are needed to improve SPIs' capacity to influence. Such measures may include seeking policy mandates, providing clear advice, and being timely with respect to policy agendas and deadlines. On the other hand, if science has poor status due to lack of credibility (e.g. after the IPCC glacier issue, Section 3.3), then totally different sides of the trade-offs should be prioritized: SPIs should emphasise quality assurance to increase credibility, communicate uncertainties, and emphasize scientific independence to show that the scientific advice is not determined by vested interests.

Regarding stages in the policy cycle we have already noted that communication of uncertainties may be beneficial in the early stages of the policy cycle (e.g. problem identification and understanding) while at later stages (e.g. implementation), communication of uncertainties may be less beneficial due to need for specific, clear and simple advice. The stage in policy cycle may also impact on other trade-offs. For instance, in the early stages of a policy cycle, supply driven approaches may be more beneficial while more demand driven strategies to provide answers to specific questions may be more appropriate towards later stages of the policy cycle.

The type of the policy problem will also affect the way trade-offs can be dealt with. Policy problems may be well-structured, moderately structured, badly structured, or unstructured (Hissechemöller et al. 2001; Turnhout et al. 2008). In well-structured problems, SPIs could follow demand-oriented strategies without suffering the associated problems, because there is political consensus about what is needed. In moderately structured problems, where different parties use science to back-up their particular positions and interests, transparency, credibility, exploration of a broad variety of views and independence are important elements as these can decrease possibilities to deploy science strategically for certain interests. In complex and badly structured problems, SPIs particularly need legitimacy, which may be strengthened by exploring a variety of perspectives and being inclusive to various actors, e.g. through broader stakeholder involvement and extended peer-review processes. This is important because science alone cannot solve societal challenges where stakes and uncertainties are high (Funtowicz & Ravetz 1993). In unstructured problems, the supply side may become predominant due to the need to communicate credibly about emerging problems. On the other hand, clear and simple messages are also necessary to raise awareness and to identify and structure the emerging problem. Thus, the appropriate ways of resolving or easing trade-offs are more often than not context dependent: merely replicating an SPI that has been perceived as successful in one context may be ineffective.

The resolution of trade-offs can also be highly resource dependent. Regarding the personal trade-off between investing time in SPIs and focusing on ‘proper’ science or policy work for instance, it seems that well-resourced SPIs (e.g. in terms of funding, power to influence, comprehensive networks, respected members) can attract more participation and dedication.

Identification of the type of trade-offs at hand – i.e. which trade-offs are *fundamental, resource dependent*, *context specific*, or *dynamic* – can significantly improve the understanding of the nature of each trade-off and facilitate the development of solutions and approaches to striking appropriate balances in dynamic contexts. The unavoidable existence of trade-offs and the lack of universally ideal options to deal with them constitutes yet another argument for highly adaptable SPIs. It is therefore important to recognize trade-offs and make them explicit, so that their management becomes an integral part of the creation, operation, evaluation and revision of SPIs.

Acknowledgements

We thank workshop participants and interviewees for fruitful discussions, and reviewers for constructive comments. Errors remain the responsibility of the authors. This work was funded by EU's Framework Programme 7, project SPIRAL: Science-Policy Interfaces for Biodiversity: Research, Action and Learning, contract number 244035.

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