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Conceptualizing credibility, relevance and legitimacy for evaluating the effectiveness of science–policy interfaces: Challenges and opportunities

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Credibility, relevance and legitimacy are often cited as determinants of the effectiveness of interfaces between science and environmental policy and serve as criteria for their evaluation. However, these concepts are hazy and have a variety of meanings. In practice, the systematic evaluation of science–policy interfaces according to credibility, relevance and legitimacy is subject to a number of difficulties and is rarely done. In this paper we offer some clarification of these concepts and show how they influence the perception and evaluation of science–policy interfaces. Our findings reveal that, while the attributes of credibility, relevance and legitimacy are helpful when reflecting on the effectiveness of science–policy interfaces, they are difficult to apply as criteria when evaluating these interfaces. To apply these concepts in a meaningful way to the task of evaluation they need to be defined specifically for the particular context of the science–policy interface concerned.

Keywords: effectiveness; trade-offs; evaluation; concepts; decision-making; policy framing.

1. Introduction

Over the past 20 years, there have been frequent calls for greater interaction between science and policy, especially in the environmental context (Lubchenco 1998; Spierenburg 2012). To this end many science–policy interfaces (SPIs) have been established, the Intergovernmental Platform on Biodiversity and Ecosystem Services (IPBES) being one of the latest at the global level (Görg et al. 2010; Spierenburg 2012). SPIs can be understood 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. (van den Hove 2007: 815)

To assess whether or not SPIs actually achieve their intended effect (on policy, institutions or processes) it is necessary to identify the determinants of their effectiveness and appropriate criteria for evaluating it. 'Credibility', 'relevance' and 'legitimacy' (CRELE)[1] have often been proposed as such determinants and criteria. In general, credibility can be understood as the quality or power of inspiring belief, relevance as the degree of relation to

the matter at hand, and legitimacy as conformity to recognized principles or accepted rules and standards (Merriam-Webster 2013). Here, we hypothesize that these CRELE attributes are, however, given different meanings in different SPI contexts and that the ambiguous use of CRELE may result in contradictory findings about the fulfilment of these criteria and thus the effectiveness of an SPI. We scrutinize the validity of these hypotheses by means of a conceptual analysis of the CRELE attributes.

1.1 CRELE as determinants of the effectiveness of an SPI

Cash et al. (2003: 8087f) suggest that efforts to mobilize science and technology for sustainability are more likely to be effective when they:

> . . . simultaneously enhance the salience [which corresponds to relevance, e.g. Eckley 2001; Farrell et al. 2006; Koetz et al. 2008; although see Wilson 2009], credibility, and legitimacy of the information they produce.

Farrell et al. (2006: 11) name credibility, salience [i.e., relevance] and legitimacy as determinants of the effectiveness of environmental assessments and consider it a 'fatal flaw' to disregard them when designing such assessments. In a similar vein, Clark et al. (2006) maintain that credibility, relevance and legitimacy are the three major determinants of the impact of global environmental assessments. Finally, Koetz et al. (2012) use the CRELE attributes as criteria for evaluating the effectiveness of SPIs. Alongside these academic debates, CRELE has also found its way into policy documents on SPIs. One example is the founding document of IPBES, which states that the platform should:

> . . . be scientifically independent and ensure credibility, relevance and legitimacy through the peer review of its work and transparency in its decision-making processes. (UN Environmental Programme 2010: paragraph 7B)

CRELE attributes are thus intimately linked to some notion of effectiveness. In general, effectiveness can be regarded as the extent to which an evaluand (i.e. an object or procedure to be evaluated) produces desired or intended outcomes (Davidson 2005b: 122). In the context of SPIs, effectiveness primarily addresses the ability to influence the behavior of intended audiences by enhancing their knowledge of the consequences of their decisions (Sarkki et al. 2014). For example, the Intergovernmental Panel on Climate Change (IPCC) is an SPI which advises governments of UN member countries on issues of climate change. Its structure has frequently been criticized in an effort to enhance the impact of the IPCC assessment reports on government policies, while interactions between the IPCC and governments have been improved in a process of organizational learning (Siebenhüner 2002a; Girod et al. 2009).

One and the same SPI can be regarded as either effective or ineffective depending on the different interpretations applied to CRELE. For example, if the knowledge that is supposed to be enhanced via an SPI is defined in negotiation with policy-makers, some maintain that this increases credibility because policy-makers will have more trust in such knowledge. Others maintain that, in this scenario, political bias will compromise scientific credibility (Eckley 2001). Here, differences in the underlying conception of credibility (political vs. scientific credibility) lead to differences in the perception of effectiveness.

1.2 Relationships among CRELE attributes

In many publications the authors specify complementarities and trade-offs between credibility, relevance and legitimacy (Cash et al. 2003; Tuinstra et al. 2006; Vogel et al. 2007; Wilson 2009; Keller 2010). Sarkki et al. (2014) list typical trade-offs, including the 'clarity–complexity trade-off' and the 'speed–quality trade-off'. The former designates a trade-off between presenting simple and clear messages (enhancing relevance) and addressing uncertainties and diverging values (fostering credibility and legitimacy), while the latter refers to a trade-off between the ability to provide rapid responses to policy needs (enhancing relevance) and time-consuming quality assessment (fostering credibility) and consensus building between plural perspectives (promoting legitimacy).

While these trade-offs are based on empirical relationships between the CRELE attributes, we hypothesize that there are also conceptual relationships at work among them. A conceptual relationship exists if a concept is, at least in some respects, synonymous with or antagonistic to another concept. We suggest that many perceived synergies between credibility, relevance and legitimacy are actually cases where these concepts constitute each other. Where such conceptual relationships exist, that is, where there are semantic overlaps, analyses of how the concepts are empirically correlated (e.g. if credibility enhances legitimacy) are of little significance. This becomes evident in a statement such as: 'We found out that surprises usually occur when they are least expected'.

The crucial point is here that non-expectancy is already logically implied in the concept of 'surprise'. Empirical studies therefore necessarily give evidence for a correlation between non-expectancy and surprise. Thus, statements such as: 'credibility, relevance and legitimacy are determinants of the effectiveness of SPIs' (Clark et al. 2006: 15; Farrell et al. 2006: 8) or 'there are trade-offs and synergies between credibility, relevance and legitimacy' (Cash et al. 2003: 8086; Tuinstra et al. 2006: 351; Sarkki et al. 2014: 195) are only meaningful if the referents of credibility, relevance and legitimacy are specified and do not conceptually overlap. Still, an empirical semantic analysis of the relationship between the

CRELE attributes is an important method in this paper. It serves to examine whether and when a story told in one vocabulary is made true by telling the identical story in some other vocabulary (Jackson 1998).

In this paper, we present a number of ambiguities present in the definitions or interpretations of the CRELE attributes and offer some conceptual clarification. We also show the effects that these ambiguities may have on the meaning of statements referring to the effectiveness of SPIs and on balancing trade-offs between CRELE attributes. Our purpose in doing so is to identify contexts when it may be legitimate and helpful to keep the CRELE attributes vague and when there is a need to be specific. Thereby, we intend to pave the way for rendering CRELE operational, to which end we offer some recommendations in Section 5.

2. Methodical approach

Concepts like credibility, relevance and legitimacy are complex and multifaceted. To capture their complexity and multiple applications, we conducted a conceptual analysis. Conceptual analysis is construed as revealing:

> . . . an illuminating set of necessary and sufficient conditions for the (correct) application of a concept, where an illuminating set is roughly one which brings out the content or the structure of the concept in such a way as to clarify the concept and indicate its relation to at least some other concepts. (Audi 1983: 90)

Our analysis was inspired by the following principles (Penrod and Hupcey 2005): The epistemological principle focuses on the distinction of a concept in the literature. Here, the guiding questions are: if a concept is clearly defined and what the variations between different definitions are. The pragmatic principle focuses on the concepts' use in explaining or describing phenomena encountered in different fields of application. As an operationalization of concepts reflects their pragmatic use in different contexts, we scrutinized approaches for specifying and measuring CRELE. The linguistic principle addresses the consistency of meaning in language use. Hence, we contrasted different uses of CRELE in texts. And finally, we relate to the logical principle: do CRELE attributes change their meaning or persist through integration with other concepts or when used in argumentative reasoning (like the justification for credibility, relevance and legitimacy as determinants of the effectiveness of SPIs)?

Our conceptual analysis consists of two steps (cf. Morse 1995). In our concept development, we identify and verify characteristics of the CRELE concept in the literature on SPIs and analyse variations in its definitions and applications. In our concept clarification we contrast different and sometimes inconsistent meanings of CRELE attributes and highlight different contexts in which particular uses prevail. This leads to the construction of idealized CRELE attributes which do not simply describe empirical phenomena, but exaggerate some of their features in order to arrive at a model of social reality.

3. The conceptual diversity of CRELE

For the sake of developing the concepts of credibility, relevance and legitimacy we discuss how these attributes are generally understood, analyse variations in their definitions and consider their applications in SPIs, that is, their use in knowledge production and decision-making and with regard to who judges what counts as credible, relevant and legitimate.

3.1 General notions of CRELE

3.1.1 Credibility

Credibility is often equated to believability (Farrell et al. 2006; Hilligoss and Rieh 2008) and in the SPI context, it has been defined as:

> . . . scientific and technical believability to a defined user [of an assessment], often in the scientific community. (Farrell et al. 2006: 9f)

Scientific standards are often cited as a yardstick for judging credibility (Clark et al. 2002). 'Credibility' can also mean 'capacity for belief' as in 'she strains her reader's credibility'. Here, the focus is on the individual disposition of a believing person and not on the object of belief. Interestingly, credibility is rarely used in this sense in the context of SPIs.

3.1.2 Relevance

Scientific findings can be relevant to policy in the sense that:

> . . . they could logically be considered in making the policy . . . (Wilson 2009: 55)

Relevance is frequently designated as salience or saliency (Siebenhüner 2002a; Cash et al. 2003). Foskett (1972: 75) further specifies relevance by distinguishing it from pertinence, which he takes to mean:

> . . . adding new information to the store already in the mind of the user, which is useful to him in the work that prompted the request.

Thus, information relevant to an issue might not be pertinent if a user already possesses this information. Some controversy exists regarding whether or not knowledge that is only potentially useful but cannot actually be used (e.g. because it is already known or not accessible) should be regarded as relevant. Eckley (2001), for example, assumes user awareness to be a precondition for an assessment to become relevant. Similarly, Farrell et al. (2006)

recommend involving potential users of assessments as a means of rendering the latter relevant.

In the SPI context, relevance may also be regarded as a measure for the relation of an issue to a policy issue or a decision to be made. The global loss of species, for example, is certainly more relevant to biodiversity policy than to air pollution policy. However, some authors question if a relationship to the matter at hand is sufficient to qualify as relevance. Jones et al. (1999) maintain that research is only relevant if its results affect decisions or reduce uncertainty to a degree that its findings will be considered in policy. For example, climate research might only influence present policy if it predicts changes that exceed a certain critical level, and only if these predictions can be made with some certainty. According to this, relevance of research depends not only on its topic but also on its results. Hence, relevance is understood here as the capacity to influence a policy. Similarly, Lemos and Morehouse (2005) regard knowledge as relevant if it addresses the problem at hand. But they recognize that this criterion does not suffice to match policy needs, which need to be clearly assessed in advance. Therefore, they regard relevance together with usefulness (provision of knowledge in forms and at temporal and spatial scales that fit with user practices and needs) and usability (accessibility and use of the information by policy-makers and other stakeholders in the form that it has been delivered) as part of the broader concept of:

> . . . level of 'fit' between the state of knowledge production and application. (Lemos and Morehouse 2005: 58)

Level of fit here reflects the degree to which the knowledge provided matches the information stakeholders believe they need to obtain.

3.1.3 Legitimacy

A general notion of legitimacy is:

> . . . the condition of being in accord with established principles. (Rantala 2008: 44)

On the one hand this definition is very broad: empirical research findings are legitimate if they have been obtained with accepted methods, a conclusion is legitimate if it follows from certain premises, and a decision is legitimate if it conforms to institutionalized procedures of decision-making. On the other hand it seems too narrow, as legitimacy is often also understood as factual acceptance and not simply as conformity to accepted rules. For example, large infrastructure projects are generally legitimate in terms of fulfilling the requirements of a licensing procedure. But the factual acceptance of such projects is often low, especially among citizens affected by the negative impacts of the projects (e.g. noise emissions from airports). As the distinction between the legitimacy of knowledge and decisions and between factual acceptance and procedural acceptability is crucial, we will discuss this further in Section 3.2.1.

At times we also encounter a notion of legitimacy as being authorized by, or endowed with, a mandate. For example, Tuinstra et al. (2006) report that a growing interest by policy-makers in the European Monitoring and Evaluation Programme under the Convention on Long-range Transboundary Air Pollution increased its legitimacy. As policy need is a key attribute in this understanding of legitimacy, it is quite close to relevance.

3.2 Specific issues in the application of credibility, relevance and legitimacy in the science–policy context

3.2.1 CRELE affected by properties, process and disposition

CRELE expresses a relation between an object and a (group of) person(s): something appears credible, relevant or legitimate to somebody. What makes knowledge credible, relevant and legitimate depends on the properties of the information being imparted, the process by which this information is conveyed and the personal disposition and perception by the recipients. This is in accord with the elaboration likelihood model (Petty and Cacioppo 1986), which suggests that arguments can change people's attitudes depending on the quality of the message they contain, peripheral cues which trigger information processing (e.g. reinforcing the argument, presentation by an accredited person), and the individual capacity of the recipient for processing a message (e.g. the tendency to favour information that conforms to personal beliefs). There is a complex social dynamic between individual perceptions and beliefs and those of groups. While this cannot be discussed here in any detail, we recognize that the perceptions of individuals do not simply sum up to group perceptions (e.g. in the sense of majority votes) but are also influenced by power or reputation.

We will now briefly delineate different perspectives on CRELE (as being effected by properties, process or disposition) expressed by different authors and subsequently analyse how CRELE attributes are specified according to these perspectives. In the context of SPIs, CRELE attributes are applied, among other things, to SPI processes and structures in general (Koetz et al. 2008, 2012), to information or output produced by SPIs (Cash et al. 2003) or to environmental assessments (Clark et al. 2006; Farrell et al. 2006). The term 'environmental assessment' is used here to encompass the entire social process by which expert knowledge related to a policy problem is organized, evaluated, integrated and presented in documents to inform policy choices or other decision-making (Farrell et al. 2006; see also the definition of SPIs by van den Hove, cited in Section 1). Thus, CRELE is sometimes conceptualized in relation to the properties of information or the way it is (co-)produced

by stakeholders in the SPI and/or is conveyed to an audience. However, the individual's disposition to regard something as credible, relevant or legitimate is rarely examined in the SPI context. In a very few cases an individual disposition towards credibility is partially covered by criteria such as trust in experts (Weichselgartner and Kasperson 2010) or 'the scientific method' (Wilson 2009: 60). The lack of analyses of personal dispositions towards knowledge at SPIs may be due to the fact that personal dispositions simply need to be taken for granted as they are usually outside the scope of SPIs. Persistent dispositions can sometimes significantly hamper the effect of SPIs (e.g. actors can ignore information when they are firmly committed to previously defined goals or options for actions (Clark et al. 2006)). Therefore, research on disposition is crucial for understanding the effectiveness of SPIs.

3.2.1.1 Credibility

The difference between the influence of properties, processes and dispositions is crucial to the conceptualization of credibility. For example, credibility can be referred to as the truthfulness of the information produced at SPIs. Equally, it can be regarded as resulting from a judgement that knowledge has been produced using accepted scientific methods and that findings have been derived and interpreted in a rigorous manner, something which can be guaranteed by a peer-review process.

The notion of credibility resulting from information properties such as data quality, model validity or consistency in inferring claims is probably most prevalent (Weichselgartner and Kasperson 2010; White et al. 2010). But how information is presented also plays a role alongside information content and how information is produced. The communication of uncertainties and problems, and comprehensibility for users, enhance credibility (Girod et al. 2009; Sarkki et al. 2014). The uptake of information also depends to a great extent on the mechanisms by which information is transferred (for an extensive overview see Rowe and Frewer (2005)). Thus, credibility is influenced by the media that disseminates information, by properties of the source which provide information (i.e. primary or secondary source, familiarity with a source), or the way information is presented (Hilligoss and Rieh 2008). Knowledge users who want to critically reflect on the credibility of information may profit from an interaction with a knowledge facilitator who can play a major role in knowledge transfer (Rowe and Frewer 2005).

Disposition research has shown that confirmation bias, that is, seeking or interpreting evidence in ways that are consistent with existing beliefs (Nickerson 1998), or availability heuristics, that is, an assessment of the frequency, probability or importance of an event being biased by the ease with which instances or occurrences can be brought to mind (Tversky and Kahneman 1974; Keller et al. 2006), influence the uptake of information. For environmental problems, Lakoff (2010) maintains that a lack of the cognitive structures or frames (hypocognition) which are needed to give sense to information hinders their acceptance.

3.2.1.2 Relevance

Relevance can be determined either empirically or by a system of rules. According to the 'destination's view' (Saracevic 1975), only those pieces of information are relevant which are judged as relevant by a user. The destination's view is common in SPIs (Lemos and Morehouse 2005; Farrell et al. 2006; Clark et al. 2006). User judgement of relevance certainly relies on many different influences (perceptions of different policy actors in the process, timing of knowledge delivery etc.). Thus, according to the destination's view, relevance is a highly context-related concept. However, there are also procedures (i.e. a system of rules) for the assessment of relevance of knowledge in science. For example, the documents retrieved by a query from an information system can be regarded as relevant, and the results given in bibliometric information (e.g. appearance of articles in certain journals, networks of citations) can express the degree of relevance. However, we are not aware of comparable rule-based processes for judging the relevance of knowledge in decision-making processes.

3.2.1.3 Legitimacy

Somewhat like relevance, legitimacy can also be viewed as outcome-related or as a rule-based, procedural concept. Legitimacy is mainly specified in relation to decisions (see also Section 3.2.2). For example, Svarstad et al. (2011: 6) regard legitimacy ('sense of justice') as the factual acceptance of a decision, which can be distinguished from distributive justice referring to the negative and positive outcomes of that decision among the people affected. Legitimacy as a sense of justice or acceptance is an a posteriori concept (Hurrelmann et al. 2005, 2009) which refers to decisions themselves rather than to the procedures of decision-making. Further, acceptance of a policy is decided subjectively and individually (Grunwald 2004). If understood this way, a decision can, for example, be regarded as legitimate if it is perceived as such by a majority of the people involved.

By contrast, for some authors legitimacy means acceptability according to criteria provided by democratic theories. To Grunwald (2004) a decision can be legitimate even if not everyone concerned accepts it as good for them. However, a 'justified expectation of acceptance' (Grunwald 2004: 112) is presumed. Here, legitimacy is determined *ex ante* and is achieved by certain procedures, which have to be accepted as bringing about legitimacy (e.g. licensing procedures for projects). In principle, the legitimacy that derives from normative rules and procedures is valid for everyone who is liable to these rules.

In the SPI context we encounter the use of legitimacy both as acceptance (Lemos and Morehouse 2005) and as acceptability (Grunwald 2004). In their definition of

legitimacy Farrell et al. (2006) mention 'acceptability' and 'perceived fairness'. Furthermore, measures referring to procedures that provide for legitimacy (e.g. coverage of stakeholders (Weichselgartner and Kasperson 2010)) as well as measures aiming at achieving perceived legitimacy (e.g. degree of consensus on knowledge or decision-making (Sarkki et al. 2014) are also mentioned at the operational level. As, in practice, not every procedurally correct decision is accepted by a majority, the discrepancy in the notions of legitimacy just described may lead to different judgements about a decision.

3.2.2 The use of CRELE in knowledge production and decision-making

In order to understand the ways in which CRELE can be applied in SPIs we here distinguish the construction of knowledge from the decision-making process. Although knowledge production and decision-making can co-evolve (van den Hove 2007) an analytical distinction between these processes is useful for clarifying different meanings of CRELE. To use the terminology suggested by Jantsch (1970) and Max-Neef (2005), norms and values (what we want to do, what we should do and how we should do what we want to do) are conceptually separated from the empirical level (what is given) and the pragmatic level (what we are capable of doing). Therefore, knowledge neither includes the evaluation of actions or decisions nor prescriptions, although it is based on a value system (e.g. referring to what is regarded as 'good' knowledge).

The task of SPIs is essentially to facilitate the integration of knowledge into decision-making. This can be done by following either a linear model or a collaborative model (Pielke 2007; Koetz et al. 2012). According to the linear model, decision-makers take up information supplied by scientists which they judge to be relevant to their policy issue. Scientific insights may either be produced in response to a demand from policy-makers or they may comprise the results of basic research which later happen to be useful for decision-making. According to the collaborative model, scientists and decision-makers instead negotiate what information is needed, what evidence is acceptable for the policy process and what the policy options are. In this process of negotiation, the boundary between science and policy in practice becomes blurred: empirical information is pooled not only by scientists but also by policy-makers and other stakeholders, while decision-making may involve scientists and other stakeholders in addition to the policy-makers.

The difference between the linear and collaborative models is key to understanding the CRELE attributes in the context of SPIs. In the linear model 'truth speaks to power' (Hoppe 1999): scientists deliver products which are then judged in terms of their credibility, relevance and legitimacy. Thus, this model is based on the idea of CRELE being a property of the knowledge produced instead of being subject to a process of negotiation.

When conceptualizing CRELE it is useful to distinguish the different stages involved in managing the knowledge generated at SPIs. The first stage involves knowledge production by a knowledge holder (see Fig. 1). The second stage comprises knowledge exchange, involving the conveying of information and its adoption or rejection by the user. In the collaborative model these two stages—knowledge production and knowledge exchange—are very much interlinked, whereas in the linear model CRELE is discussed during the knowledge production stage and is negotiated again at the knowledge exchange stage. In a third stage, policy decisions are made (or policy recommendations put forward), which are highly influenced by knowledge exchange according to the collaborative model. In the real world, there are certainly many gradations between these three stages and between the collaborative and the linear models. However, distinguishing these stages serves to illustrate how the ideas and importance of CRELE attributes vary according to the stage at which they are applied.

Credibility is often referred to in the context of knowledge production where it is understood as the scientific adequacy of knowledge (Cash et al. 2003; Farrell et al. 2006; Clark et al. 2006). Frequently, however, the credibility of knowledge is re-negotiated when it enters the policy arena (Siebenhüner 2002a; Eckley 2002). In these cases, credibility is taken to mean not only scientific credibility but also political credibility. The credibility measure developed by Keller (2010), based on the perception of credibility by a broader audience, gives a good example of how credibility is rated

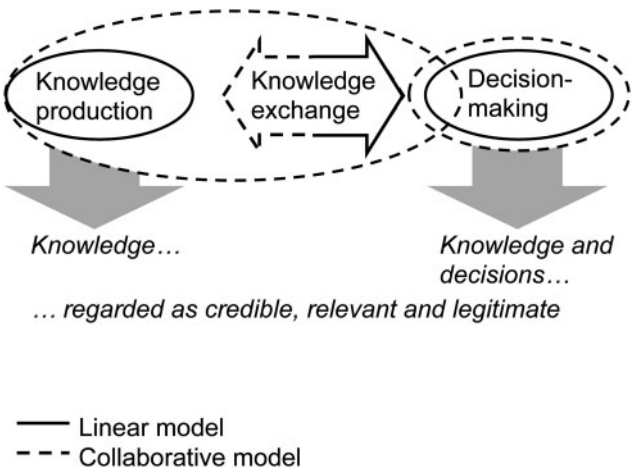

Figure 1. A simple model of an SPI. We identify different stages in knowledge management: knowledge production, knowledge exchange (including knowledge presentation and adoption) and decision-making. In knowledge production and knowledge exchange, credibility, relevance and legitimacy apply only to knowledge; in decision-making, legitimacy also refers to the decisions themselves, while credibility and relevance refer to the knowledge used in decisions.

during the knowledge exchange phase. This measure divides newspaper stories into those that treat a science assessment organization as a reliable or authoritative source of scientific information and those that suggest the science assessment organization is the subject of controversy.

Whether scientific findings are relevant in terms of advancing scientific progress is a topic which is rarely taken up in the debate on the relevance of SPIs. Many criteria for assessing relevance neither cover the novelty aspect of knowledge nor do they focus on the way in which knowledge is motivated or produced but on the way it is transferred (e.g. coverage of a range of audiences, comprehensibility for users etc. (Girod et al. 2009; Weichselgartner and Kasperson 2010)).

While credibility and relevance relate to knowledge production and exchange, legitimacy often relates to either decisions or action:

> A public policy or action is legitimate when citizens have good reasons to support or obey it. (Fung 2006: 70; Weatherford 1992)

According to this view, citizens certainly have good reasons to disregard decisions which are based on false premises. In this case, we see a close connection between legitimacy and credibility. Legitimacy is often equated with justification (Grunwald 2004; Bernstein 2005). There are two sorts of validity claims which may demand justification (Habermas 1973, 1981): normative rightness and truth. Thus, a decision can be right and a scientific claim correct. While rightness claims refer to the binding character of normative rules and principles, truth claims relate to the empirical verifiability of observations.

The conceptual relation between credibility and legitimacy becomes evident in a statement such as:

> . . . legitimacy refers to the credibility of the information. (Contandriopoulos et al. 2010: 459)

In this statement, both terms are seemingly used interchangeably. Vogel et al. (2007: 357) point out that legitimacy often serves as a justification for truth and rightness claims:

> . . . Scientists frequently assume that knowledge that has emerged from a rigorous process of data gathering, hypothesis testing, empirical or model verification, and peer review is the 'truth' (or at least a superior truth) because of the 'expert' nature of scientific knowledge and, therefore, ready for transfer to and use by end-users. To practitioners, legitimacy may be derived from considering and addressing key stakeholders' values and concerns and inclusion of non-scientific knowledges.

In the SPI context, many authors refer to legitimacy in the decision-making context alone (Tuinstra et al. 2006; Svarstad et al. 2011). Thus, the perception that credibility is scientific and legitimacy is political is widespread. Equally, however, legitimacy can also be regarded in terms of scientific legitimacy and credibility as political credibility (Wilson 2009).

When the legitimacy of truth claims refers to credibility the question arises whether relevance can also be justified and thereby awarded legitimacy. This is certainly the case when scientists try to convince policy-makers that certain findings should lead to certain policy actions or when policy-makers defend these findings as being relevant to their decisions. Thus, if legitimacy is understood as justification, it cuts across the credibility of knowledge, relevance to a policy and the political rightness of a decision.

3.2.3 Who makes a judgement on CRELE?

Whether or not an SPI is credible, relevant or legitimate is a matter that is subject to either stakeholder or expert judgement. Stakeholders are a heterogeneous group which can be conceived either narrowly (e.g. only decision-makers) or broadly (e.g. in an interactive SPI all those people or organizations concerned about, affected by, with a vested interest in, or involved in some way with the issue at hand). We will discuss different rationales for the involvement of stakeholder and expert knowledge below. Alongside the findings of stakeholder theory, there are a number of criteria which determine whose judgement on CRELE counts:

- *Relation of an SPI to the potential users of results:* In an SPI conceived as an agency–client relationship, stakeholder acceptance is more important than in the case of a loose relation to knowledge users. Similarly, the user group is often more evident in the case of demand-driven knowledge than supply-driven knowledge. Users or funders also determine the purpose of evaluating effectiveness. Either the overall quality or value of an SPI is to be determined (summative evaluation) or feedback is to be given to improve it within the SPI process (formative evaluation) (Davidson 2005a). In summative evaluation it is usually those to whom the SPI is accountable who will judge its CRELE. Formative evaluations are often self-evaluations.
- *Different stages of knowledge processing in SPIs* (see Fig. 1)*:* What is required of CRELE may differ between the stages of knowledge production, knowledge exchange and decision-making. In knowledge production scientists have a more powerful mandate to make judgements on relevance (also in terms of decision-making) than in the actual decision-making stage. This might appear curious. But like a patient who cannot judge the relevance of different medications in relation to his illness, a potential user might not be able to judge the relevance of knowledge to a policy issue. Further, not only might a patient not know what he is suffering from, he might not even know the right questions to ask in order to find out about his disease: he only has a vague information

need and the desire to know an unknown (Saracevic 1975; Hjørland 2010). Therefore, at the stage of knowledge supply, knowledge holders as well as policy-makers also need to decide on relevance.

- *Type of knowledge at issue:* Judging the credibility of scientific, administrative or other forms of knowledge is often institutionalized. Scientists keep a close watch on credibility in scientific publications, and administrators control the fulfilment of technical standards in licensing procedures. Thus, in many cases experts are needed to judge the credibility of specific knowledge. However, expert knowledge is sometimes contested by a broad array of non-experts outside the context of institutionalization.
- *Certainty of knowledge and agreement on values:* Chess et al. (1998) recommend that, when values are contested, stakeholders should be involved if there is sufficient certain knowledge, and both scientists and stakeholders should be involved if there is insufficient certain knowledge. Values are often contested in relation to policies which are embedded in a complex physical, social and institutional setting (e.g. policies on biodiversity and ecosystem services). Here, trade-offs have to be made between different objects of conservation (e.g. habitats vs. provisioning services from agricultural land use), policy sectors or scales (e.g. carbon sequestration as a global benefit vs. recreation as a local benefit). When there is broad agreement on values, experts or administrators are entitled to deliberate. Here, the decision-making process is often institutionalized and thus legitimated in advance by a set of rules.

This list of criteria for determining who may make a judgement on CRELE is not exhaustive, and a systematic theory on this topic would certainly be helpful. However, it has become clear so far that, depending on the issue at hand, the group of people who will determine the CRELE attributes and judge knowledge or decisions on the basis of these attributes may be very diverse. As a consequence, each SPI needs to define anew its understanding of CRELE.

4. Effects of the diversity of CRELE attributes on their use

To conduct concept clarification we here analyse the meaning of CRELE attributes in different contexts. We elaborate these attributes by contrasting the changing meaning of CRELE attributes according to their use.

4.1 CRELE attributes as determinants of the effectiveness of SPIs

The purpose of SPIs is to acquire and discuss knowledge as a means of supporting decision-making. Whether or not SPIs are judged to be effective depends on how knowledge is considered to best support decision-making. Rationales for public participation in environmental policy and governance (instrumental, substantive and normative rationale, Wesselink et al. 2011; see Table 1) here help to distinguish different SPI settings and purposes of including knowledge from different stakeholders in decision-making which may in turn impact the evaluation of the effectiveness of SPIs. Further, CRELE attributes can differ in their importance according to the underlying rationale. The instrumental rationale is concerned with providing for a smooth implementation of decisions already framed. It is therefore important to address the ideas of individuals or organizations with the power to block decisions. Here, an SPI is effective if the implementation of a decision is easily done. The substantive rationale aims to obtain stakeholder knowledge only insofar as it adds value to the quality of a decision in terms of set criteria (e.g. criteria for environmental quality or economic sustainability). Only those individuals who are able to offer additional knowledge relevant to the decision-making context have a voice. Knowledge can be used in different ways here (Weiss 1979). The decisions themselves can be subject to debate and policy-makers 'inform themselves of the range of knowledge and opinion in a policy area. (Weiss 1979: 429) (interactive model)' Alternatively, decisions are already made and knowledge is needed for the practical implementation of a decision (problem-solving model). Here, an SPI is effective if decisions are sound and involve as much certain knowledge as possible. The *normative rationale* relates to the process of actor involvement. Fairness and democratic rights are generally the reasons for considering actors' views and concerns. These views and concerns have to be taken seriously, independently of their content: stakeholder involvement here is an end in itself. Here, an SPI is effective when SPI processes ensure a fair consideration of actors' concerns. The effectiveness of SPIs thus refers to different characteristics or processes depending on the different underlying rationales.

The underlying rationale offers a context for understanding and determining the importance of the CRELE attributes (see Table 1). Credibility is the most important attribute for the substantive rationale as the aim here is to achieve high quality knowledge. In this context, credibility will mainly be regarded as a property of knowledge that is secured within the realm of scientific knowledge production or by meeting administrative standards. Credibility is also important in the context of the instrumental rationale if it helps to convince those people whose acceptance is needed for implementation. The credibility of the knowledge is thus a determinant for gaining acceptance, and in this respect it is closely related to legitimacy (Wilson 2009). According to the normative rationale, credibility is initially irrelevant, as any information from stakeholders and different forms of knowledge should be taken seriously (e.g. local knowledge (cf. van Herzele and Woerkum

Table 1. Different rationales for participation in environmental policy and governance (after Wesselink et al. 2011, with major additions)

	Instrumental rationale	Substantive rationale	Normative rationale
What is included?	Policy-makers' concerns; politically selected knowledge and values	Policy-makers' concerns; no political selection of knowledge and values (interactive model) or no debate on policy values (problem-solving model)	Stakeholders' knowledge and values
Who is included?	Those whose approval is needed for implementation	Those who have additional knowledge	Those who have a stake
Status of decision	Already framed, but needs approval	Still being debated (interactive model) or already made (problem-solving model)	Still being debated
Idea of effectiveness	Amount of time taken for implementation	Fulfilment of qualitative standards	Fair consideration of stakeholder concerns

2008; Waylen et al. 2010)). However, in the case of contradictory or contested information credibility needs to be negotiated, especially if decision-making is based on such information.

The relevance of knowledge is certainly important when applying the substantive and instrumental rationales. As the substantive rationale focuses on properties of knowledge such as its quality and comprehensiveness, it is of no interest who provides relevant information. Relevance is determined only by the capacity to provide additional information in relation to a given issue. According to the instrumental rationale, however, only that information is relevant which helps to convince stakeholders about a favoured policy (Pielke 2007). In principle all stakeholder concerns and viewpoints are relevant in the context of the normative rationale. Here the focus of relevance is shifted from a fixed relation between knowledge and the issue at hand to a dynamic stakeholder perception of what is relevant. What becomes relevant in the end is therefore unclear at the beginning and is the outcome of a process of deliberation (Renn and Schweizer 2012). In this case, relevance actually results from legitimacy.

Legitimacy is important with regard to each rationale. In the context of the substantive rationale, legitimacy refers to the unbiased and comprehensive appreciation of a given set of information, focusing on the way in which information is processed. According to the instrumental rationale, legitimacy is based on the consent of stakeholders, which is required in order to implement a decision. It should be noted that the involvement of these stakeholders does not necessarily comply with requirements of fairness. This is because fairness is a concept which belongs to the realm of the normative rationale. Here, legitimacy relates to a balanced consideration of stakeholder concerns in knowledge production and decision-making.

Thus, depending on the underlying rationale for including knowledge, the importance of CRELE attributes differs according to the rationale (e.g. legitimacy has a greater importance for the normative rationale than for the instrumental rationale). Further, the meaning of CRELE attributes depends on the rationale (e.g. legitimacy meaning support by those who could prevent the implementation of a decision according to the instrumental rationale, comprehensive and unbiased integration of information according to the substantive rationale and balanced consideration of stakeholder concerns according to the normative rationale). Likewise, the group of persons who may judge on CRELE differs according to the rationale. Thus, ideas of effectiveness also differ very much in their dependence on the rationale followed (see Table 1). As a consequence, maintaining that CRELE contributes to effectiveness without clarifying the purpose of knowledge inclusion in decision-making processes is in many cases a truism because some notion of a CRELE attribute can always be regarded as contributing in some way to the effectiveness of SPIs.

4.2 Trade-offs and synergies between credibility, relevance and legitimacy

Balancing trade-offs and synergies between credibility, relevance and legitimacy is only possible if each of these attributes can be assessed in some way: if it is possible to judge whether these attributes have been fulfilled to a greater or lesser extent or if they are enhanced or reduced by certain activities. However, the outcome of trade-offs between CRELE attributes depends in turn on how CRELE is understood. As CRELE attributes cannot be measured directly, criteria for assessing CRELE attributes have to be defined and applied. We have shown in Section 3.2 above that credibility, relevance and legitimacy are sometimes conceptually related to one another. Here, we offer some evidence suggesting that criteria for assessing the different CRELE attributes are sometimes used interchangeably because they are not conceptually clearly distinguished from each other. Thus, trade-offs can very much depend on the criteria used and

one and the same criterion can operationalize different CRELE attributes.

According to Vogel et al. (2007: 354), knowledge that has emerged from a rigorous process of gathering data, testing hypotheses, verifying empirical evidence or models, and peer review is legitimate knowledge in terms of scientific adequacy. Similarly, Weichselgartner and Kasperson (2010) found that improving data and/or information sources improves the legitimacy of an assessment. However, the same authors also regard data reliability and adequacy of methods as an aspect of credibility.

White et al. (2010) regard the informative presentation and comprehensibility of knowledge as criteria for credibility, Girod et al. (2009) as criteria for legitimacy. Weichselgartner and Kasperson (2010) consider 'trust between producer and user' as a criterion for legitimacy, albeit one which other authors associate with credibility (Lemos and Morehouse 2005). We assume that this confusion arises because credibility can be understood as one aspect of the legitimacy construct, that is, if a piece of information is considered credible, this renders its use (e.g. for decision-making) legitimate. This corresponds to our finding that legitimacy sometimes refers to the justification of truth claims. However, there also seem to be cases when, conversely, legitimacy enhances credibility. Miller (2001) assumes that credibility is enhanced by establishing the formal authority of the Subsidiary Body for Scientific and Technological Advice to the UN Framework Convention on Climate Change to make rules regarding measurement standards through consensus voting:

> In this manner, the normative weight of collective agreement helps buttress the credibility of value-laden choices. (Miller 2001: 495)

However, establishing authority and attributing normative weight to value-laden choices are generally regarded as enhancing legitimacy. These contradictory findings result from similar conceptualizations of credibility and legitimacy and a lack of reference to either knowledge production or decision-making. Credibility and legitimacy are provided for through similar processes (e.g. peer-review process for credibility/legitimacy in knowledge production, bestowing of formal authority for gaining credibility/legitimacy of decisions). This makes it hard to classify knowledge or decisions as either credible or legitimate.

Sometimes, credibility also has a meaning similar to relevance. According to White et al. (2010) a lack of clarity about how groundwater shortage influences water supply reduced the relevance of a water consumption and availability model. However, model specificity and accuracy are also regarded as a constituent of credibility (Siebenhüner 2002b; Vogel et al. 2007; White et al. 2010). Thus, if the model does not reflect water consumption and availability accurately it is not credible and is therefore irrelevant. This seems plausible, as the usefulness of a model which does not produce correct results is likely to be reduced. Nonetheless, in this case credibility constitutes relevance. In contrast, according to the speed–quality trade-off (Sarkki et al. 2014), enhancing credibility decreases relevance. Therefore, it does not seem feasible to assume that there is a trade-off between credibility and relevance in general. Further, the speed–quality trade-off is much greater if credibility is understood as scientific and not as political credibility. As Eckley (2001: 12) points out:

> . . . it may be only important to be credible enough for decisions to be taken.

As knowledge exchange has a great influence on political credibility, the effect of time-consuming scientific credibility on political credibility might not be very substantial. Therefore, it can be important to distinguish between the knowledge production process and the decision-making process. Still, there are also many cases when scientific credibility and political credibility can be closely interlinked, for instance, when decisions are postponed in the confidence that they will eventually be addressed when scientific credibility is regarded as sufficient to back them up (Eckley 2002).

Finally, relevance and legitimacy are sometimes also conceptually related. Eckley (2001: 8) maintains that:

> . . . an effort to increase legitimacy by taking into account the concerns of a particular stakeholder group may also have the effect of increasing an assessment's salience to those in that group.

This might be because legitimacy can be viewed as part of the relevance concept. This view is supported by Mitchell et al. (1997) who regard the relevance of stakeholder concerns as constituted by legitimacy, power and urgency.

Alongside the difficulty of establishing an assessment criterion for different CRELE attributes, there is often also uncertainty about whether the fulfilment of such a criterion enhances or reduces CRELE. Tuinstra et al. (2006) report that a clear demarcation between science and policy maintains the legitimacy of science. At the same time, the political mandate of organizations involved in conducting scientific assessments (e.g. IPCC and IPBES) is often regarded as a key element in ensuring legitimacy (Miller 2001; Koetz et al. 2008). Hence there seems to be a trade-off within the concept of legitimacy here, which might be due to a confusion of legitimacy in knowledge production and in decision-making. Such trade-offs can also appear for other CRELE attributes. For example, there can be a large discrepancy between scientific and political credibility, when scientific truth is not what policy-makers want to hear.

Sarkki et al. (2014) think that communication of uncertainties increases credibility but lowers relevance (the clarity–complexity trade-off). However, Girod et al. (2009) maintain that illustrating uncertainties enhances

relevance, as this is a precondition for effective uncertainty management. A clarity–complexity trade-off would not arise here. This example shows that it is hard to determine relevance without specifying the issue at hand. For some issues such as uncertainty management, excessive simplification of knowledge renders it irrelevant. As a consequence, a trade-off within the notion of relevance arises between complexity and clarity. Similarly a trade-off between different aspects of relevance appears when deciding between local specificity (very relevant to some people) and broad coverage (less relevant to many people) of environmental models or scenarios.

To conclude, the question as to whether there are trade-offs and synergies between credibility, relevance and legitimacy cannot be answered generally in a meaningful way. There are two reasons for this. First, there is some degree of conceptual overlap between the CRELE attributes, which frequently means that the same assessment criteria are applied to different attributes. When this occurs, it becomes difficult to identify clear trade-offs between credibility, relevance and legitimacy. Second, because of a lack of specificity regarding the CRELE attributes, there is considerable room for interpretation about whether or not a certain activity enhances or reduces CRELE. Consequently, the assessment of trade-offs between CRELE attributes is currently based more on personal interpretation than on a transparent procedure.

5. The way forward for CRELE as a criterion for the effectiveness of science–policy interfaces

Credibility, relevance and legitimacy have become state-of-the-art criteria in the context of SPIs. Framing the effectiveness of SPIs by reference to these attributes has contributed considerably to the adoption of scientific knowledge in policy (e.g. in environmental assessments) (Clark et al. 2006; Farrell et al. 2006). As a heuristic tool, CRELE has proved suitable to inspire research on the effectiveness of SPIs (Keller 2010; Sarkki et al. 2014). In this paper, we have examined whether CRELE is useful beyond a general framing of SPIs and whether its attributes are feasible criteria for evaluating the effectiveness of SPIs.

Using CRELE to evaluate the effectiveness of SPIs comes up against the problem posed by its divergent meanings. CRELE can be regarded either as a property of knowledge, or as being determined mainly by processes between different actors, or as being influenced mainly by individual disposition (or as any combination of the three). It can refer to different stages in knowledge management: knowledge production, knowledge exchange or decision-making. And finally, given that knowledge is credible, relevant or legitimate only for specific individuals, the idea of CRELE is dependent on who judges CRELE and how the similarly vague terms ‘effectiveness’ and ‘SPI’ are conceived: as the composition of individuals and organizations differs between SPIs, so will the notion of CRELE. When CRELE is used to refer to the effectiveness of SPIs, notions of CRELE will change according to notions of effectiveness and of SPIs.

We have shown that CRELE is actually applied in different ways. Both the merits and the shortcomings of the CRELE attributes are based on their polysemy. As ‘boundary objects’ (Star and Griesemer 1989; Star 2010), the attributes provide a basis, on the one hand, for bringing together the knowledge, interests and concerns of science and policy (and other stakeholders). All the groups involved agree on the importance of these attributes for SPIs, although they are often understood in different ways. As positively connoted concepts (‘thick concepts’ (cf. Väyrynen 2009)) they are readily accepted even by different policy sectors (e.g. agriculture, infrastructure development, nature conservation) and other groups with divergent policy aims. On the other hand, these advantages are compromised by the limited ability of the CRELE attributes to provide clear guidance for the design and evaluation of SPIs. As we have shown, statements such as ‘there are trade-offs between credibility, relevance and legitimacy’ (Tuinstra et al. 2006: 351; Sarkki et al. 2014: 195) become meaningless if these concepts are not specified. In science, however, formulating meaningful statements is a vital requirement. This also holds for politics unless it is based on persuasion by rhetorical tricks alone. In summary, CRELE can be regarded as a ‘conceptual cluster’ (Jax 2006) which serves well for communicating at the science–policy boundary. However, for tracing arguments using CRELE in particular science–policy contexts CRELE attributes need specification.

The notion of CRELE that prevails in any specific case will have many practical consequences. For example, if relevance is regarded as a concept which is influenced mainly by social processes between different actors, research funding will likely be allocated to research on how these actors interact and on the effectiveness of strategies to render topics relevant. Thus, the task of properly specifying what exactly is meant by CRELE in practical contexts will certainly be a challenge in the future.

Most knowledge and most decisions are credible, relevant or legitimate at least according to some notion of CRELE. For example, local knowledge is highly credible for stakeholders but often does not meet standards of scientific credibility. This leads to the question of which notion is most suitable in a given context and who has the mandate or the power to determine what is the ‘right’ understanding of CRELE. Different parties will try to advocate their own formulation of CRELE and to dominate the discourse on CRELE. As the struggle for the

power to define and interpret terms that are pivotal to enforcing a certain policy is a common phenomenon (Schiappa 2003), we assume that this already occurs in the case of CRELE.

Although CRELE is regarded as an important and desired characteristic of SPIs, so far it has rarely been used in any systematic, concrete evaluation of SPIs. In order to include CRELE in the mainstream for the evaluation of SPIs, three tasks will need to be addressed:

- *Linking CRELE and the SPI's aims explicitly when setting up a new SPI:* As different SPIs have different aims, CRELE needs to be conceptualized in a way that reflects these. As this is an important normative step it requires legitimation and transparent communication by all the stakeholders involved. This task is rarely undertaken consciously when setting up an SPI. Rather, the nature of CRELE as a boundary concept tempts users following divergent policy agendas to keep it vague.
- *Making the underlying concept of CRELE and the trade-offs among its attributes transparent:* As CRELE concepts and perceptions in existing SPIs are often hazy and encompass a variety of meanings, the trade-offs among its attributes remain unclear, as do the major tensions that may arise (Sarkki et al. 2014). Thus, it is vital to make explicit which concept of CRELE has been chosen to identify trade-offs and to find ways of evaluating SPIs regularly according to effectiveness and other criteria. The IPBES process would be an ideal test case for such an approach (Vohland et al. 2011).
- *Adapting the criteria for evaluation to the chosen notion of CRELE:* In the few systematic evaluations of CRELE undertaken so far, the reasons for selecting certain criteria for rendering these concepts operational have remained unclear (Weichselgartner and Kasperson 2010; Keller 2010; White et al. 2010). However, it is important that these criteria adequately reflect the intended notion of CRELE. To avoid arbitrariness, a systematic elaboration of criteria which cover the intended notions of CRELE would certainly be helpful (Sarkki et al. 2014).

To develop and adapt such criteria for CRELE would be a major achievement for SPIs as this would in general, improve their transparency and clarify their functions to any stakeholder involved. Also, developing such criteria within an SPI through agreement between the multi-stakeholder bodies would in itself support the building up of credibility and legitimacy of the SPI. These bodies could specify how the functions and principles of an SPI are actually met but also would make clear the challenges involved in their implementation. This would contribute to a more transparent evaluation and reflection of an SPI and help to avoid its performance being either evaluated only politically in a positive way from inside the SPI (e.g. by letting its own bodies report on the 'success') or from the outside with opponents probably using a notion of CRELE that makes criticism easy.

As the recent controversies over the IPCC as the global SPI 'flagship' have shown (Hulme 2009; Beck 2012), it will be essential in the future that SPIs reflect more carefully on their own understanding and on the variety of internal and external perceptions of the CRELE attributes in their work, especially when it comes to evaluation processes. We hope that our paper helps by showing the major pitfalls in this respect.

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Notes

1. We use 'CRELE' as a collective term for credibility, relevance and legitimacy (cf. Sarkki et al. 2014); when we refer to credibility, relevance and legitimacy as singular concepts, we write these words out or use the term 'attribute' (e.g. 'conceptual relations between credibility, relevance and legitimacy', 'trade-offs between the CRELE attributes').

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