Science as a "fixed point"?
Quantification and boundary objects in international climate politics

Bård Lahn [a, *]
Göran Sundqvist [b]

[a] Center for International Climate and Environmental Research – Oslo (CICERO).
[b] Department of Sociology and Work Science, University of Gothenburg.

* Corresponding author. E-mail bard.lahn@cicero.oslo.no

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Abstract

Our understanding of climate change is dominated by quantified scientific knowledge, with science and politics usually seen as operating separately and autonomously from one another. By investigating a particular fact box in the IPCC's Fourth Assessment Report (AR4), this paper challenges the assumption that science and policy can be clearly delineated. The so-called "Bali Box" gained a prominent role in negotiations leading up to the Copenhagen Conference in 2009, as it was widely seen as providing a "fixed point" – a quantified scientific answer to the question of equitable effort-sharing between North and South. This understanding of the Bali Box triggered a backlash, however, when the hybrid character of the box as an assemblage of science, political considerations and moral judgements became evident to actors in the negotiations. The paper employs the notion of boundary objects to analyse the history of the Bali Box, and argues that climate politics will benefit from a richer understanding of the interplay between science and policy. Moving beyond characterizations that place the Bali Box on either side of a clear boundary between the scientific and the political, we suggest focusing instead on what the Box as a hybrid product is doing, i.e. how it simplifies and quantifies, what it covers and what it leaves outside.

Keywords

IPCC; UNFCCC; science/policy; boundary objects; North/South equity

1. Introduction

In what has been described as a landmark ruling, the Hague District Court on 24 June 2015 ordered the Dutch Government "to limit the joint volume of Dutch annual greenhouse gas emissions (…) by at least 25% at the end of 2020 compared to the level of the year 1990" (Hague District Court, 2015, p. 53). The rationale for the Court's ruling was that the Netherlands' current policy of reducing emissions by 17% by 2020 "is below the norm of 25% to 40% for developed countries deemed necessary in climate science and international climate policy" (Hague District Court, 2015, p. 1). Although the Government has appealed the Court's order, the ruling is being hailed as setting a global precedent for future legal action to force governments to reduce greenhouse gas emissions in line with scientific findings (Schiermeier, 2015).

This paper takes its point of departure in two observations regarding the understanding of climate science and policy that underlies the Court's decision. First, by obligating the Dutch Government to increase its emission reduction target for 2020 by eight percentage points (from 17% to 25%), the ruling illustrates the dominant role of scientific, quantified *precision* in discussions of climate policy. Secondly, the ruling's invocation of a "norm (…) deemed necessary in climate science" is based on a particular view of the relationship between science and policy, in which science and policymaking is *clearly separated* – with the former being expected to deliver objective, quantified recommendations to the latter for implementation.

This dominance of quantified scientific knowledge, and the understanding of science and policy as clearly separable spheres, is not limited to the ruling of the Hague District Court. Rather, it characterizes the debate on climate change and climate policy at most levels in most countries (Demeritt, 2001; Wynne, 2010). At the same time, the specific numbers on which the Court's ruling is based – the "norm of 25% to 40%" emission reductions "deemed necessary in climate science" – are particularly well suited to investigating how this scientific dominance is played out, and the effects it may have on public debate on climate change.

The numbers "25% to 40%" originate from a fact box in the Fourth Assessment Report (AR4) of the Intergovernmental Panel on Climate Change (IPCC). Despite its modest location on page 776 in the report from the IPCC's Working Group III (Gupta et al., 2007), this particular box has had an influence on climate policy that goes far beyond the Dutch court system. In particular, it became closely linked to the process of negotiating a new international agreement on climate change under the UN Framework Convention on Climate Change (UNFCCC) leading up to the Conference of the Parties (COP) 15 in Copenhagen, 2009. When these negotiations started at COP 13 in Bali, the box played such a prominent role that it came to be known among negotiators and observers as the "Bali Box".

In the UNFCCC negotiations from 2007 to 2009, many actors initially saw the Bali Box as providing a scientifically justified "fixed point" that promised to solve the contentious issue of equitable effort-sharing between the industrialized countries of the North and developing countries of the South. Over the course of negotiations, however, the numbers in the Bali Box came to be questioned and contested, provoking politicized discussions and adding to the tensions between negotiating parties that ultimately led to the failure of COP 15 in Copenhagen.

With the adoption of the Paris Agreement in 2015, the UNFCCC negotiations have entered a new phase in which the acrimony of Copenhagen and the distributional conflict between

North and South is seemingly replaced with a new collaborative spirit based on a “bottom-up” approach to effort-sharing (Chan, 2016; Rajamani, 2016). Our contention, however, is that the story of the Bali Box still holds valuable lessons to climate science/policy communities, firstly because questions of equity remains fundamental to understanding the politics of climate change (Klinsky et al., 2016), and secondly because it points to another key issue in understanding climate change politics, namely: how are the boundaries drawn between science and policy in the area of climate change, and what consequences do these boundaries have for public debate on climate related issues?

In discussing the latter of these questions, this paper draws on theoretical resources from the field of Science and Technology Studies (STS) in order to analyse how the IPCC balances science and policy. A detailed analysis of the Bali Box and the role it played in the UNFCCC negotiations is used to illustrate the work of the IPCC and the problems that might occur when public debate about climate change rests on the notion of a clear distinction between science and policy. The analysis is based on a selection of scientific papers explicitly discussing the numbers presented in the Box (den Elzen and Höhne, 2008; Baer, 2008; Winkler et al., 2009), as well as other documents referring to the Bali Box numbers and our own observations of the negotiations in the period 2007–09.

The paper argues that the controversy surrounding the Bali Box arises from a classical purist ambition to purge science from politics, and that this ambition risks changing climate change from “pure science” to “pure politics” whenever scientific numbers are questioned or disputed. In contrast to the traditional, purist approach, we advance the argument that the Bali Box should be understood as both scientific and political – as an attempt to solve a complex problem through quantification and simplification. The success or failure of the Bali Box and similar initiatives is not to be found in its purity as either scientific or political, but in the extent to which it succeeds in simplifying complex and controversial issues. On this basis we identify a number of lessons to be learnt from how the Box was represented and the process through which it was brought about, and what this might mean for the role of science in discussions on climate politics and equity.

2. Science/policy interactions and climate change

Scientific knowledge is crucial for rendering environmental problems visible and governable. A close relationship between science and policy in the environmental field is therefore seen as desirable by scientists and policymakers alike. At the same time, there is a clear ambition to maintain a clear boundary between the activities of science and policymaking. Paradoxically, therefore, many actors seem to argue for both separation and integration at the same time (Sundqvist et al., 2015). Even in social science studies of the interplay between science and policy, arguments for integration and cooperation frequently start from the implicit assumption that the two spheres exist in clear separation from each other. This is evident in the strong focus that is often placed on the need for “building bridges” and overcoming “barriers”, “resistance”, or “misunderstandings” between what are implicitly understood to be clearly demarcated spheres of science and policy (e.g. Lemos & Rood, 2010).

In contrast to this mainstream understanding of the science-policy relationship, STS scholars argue that studies of science as an institution and body of knowledge should be actor-oriented and start from actions and practices. It is through such practices – in the form of *boundary work* (Gieryn, 1999) – that relevant actors are making demarcations between science and other activities, such as governance and politics. Thus, how boundaries are drawn, and with what consequences, become empirical questions to be analysed and explained rather than taken for granted.

A closer look at actual practices in the science/policy interface shows that – despite the widespread assumption of separation – a number of organizations explicitly seek to achieve a hybrid identity combining science and policy. These so-called *boundary organizations* (Guston, 1999) mobilize science for policy objectives and are characterized by their links to both scientists and policymakers. However, actors involved in boundary organizations also perform boundary work to protect their authority, using labels such as "science", "policy" and "hybridity".

In order to understand how boundary work achieves the stability needed to maintain boundaries over time, the STS literature points to so-called *boundary objects* – objects that enable interaction, engagement and unity between actors from different social worlds, while also allowing for multiple interpretations and understandings (Star and Griesemer, 1989). Boundary objects should be understood as work arrangements on an organizational level, as tools for cooperation between people that want to achieve something; that is, they help actors to act in complex institutional settings, creating "shared space" (Star, 2010). Thus, boundary objects are "plastic enough to adapt to the local needs and constraints of the several parties employing them, yet robust enough to maintain a common identity across sites" (Star, 1989, p. 21) – for instance between science and policy, or between academic disciplines, expert groups and relevant policy organizations – but without complete consensus as a necessary condition (Star and Griesemer, 1989, p. 391). They make cognitive unity possible, based on communication among actors holding different interpretations of the object.

As a useful tool for analysing actions and practices among organized actors, the notion of boundary objects does not require an essential definition. Almost anything could be a boundary object, but few actually are, in the concrete practices of heterogeneous actors (Star, 2010). However, some types of entities that could become boundary objects include "standards", "guidelines" and "ideal types" such as "a diagram, atlas or other description" – entities that may be fairly vague, but that could serve as "a 'good enough' road map for all parties" (Star and Griesemer, 1989, pp. 392, 410). When a boundary object has been established it is often taken for granted, becoming a "black box" (Latour, 1987) that renders assumptions and contingencies invisible. In this way, boundary objects are able to provide a foundation for forging stable science-policy assemblies.

2.1 The IPCC as a boundary organization

The establishment of international institutions in the area of climate change can be seen as a paradigmatic example of how science and policy are mutually constitutive (Miller, 2004). The IPCC was established in 1988 by the World Meteorological Organization (WMO) and the United Nations Environment Program, to provide the governments of the world with a clear scientific view of what is happening to the world's climate. Four years later, the UNFCCC was adopted to provide a framework for hosting and organizing international negotiations on limiting greenhouse gas emissions.

The existence of the IPCC and the UNFCCC as separate organizations is sometimes taken as signalling a clear division of labour between science and policy, with science providing summaries of results and scientific advice as a basis for political negotiations on policy. This understanding, however, overlooks how the two organizations are closely intertwined. Negotiations under the UNFCCC are based on the scientific understanding presented by the IPCC of the climate system as a global entity, while the work of the IPCC is profoundly shaped by considerations of policy relevance and usefulness to the political process (Demeritt, 2001; Miller, 2004).

The IPCC describes its work as being "policy-relevant and yet policy-neutral, never policy-prescriptive".[1] This formulation functions as a mantra for the organization: to be close to policy-making, but not too close. In its own eyes, the IPCC is nothing more than an organization that summarizes scientific results. At the same time, the summaries should be policy-relevant – i.e. it should have some form of impact on policy. Thus, the IPCC is organized in a way that tries to balance the separation and integration of science and policy (Sundqvist et al., 2015). In order to achieve this, it employs a mixed-mode approach, which in sequential steps tries to achieve both scientific autonomy and policy-influenced science.

This makes the IPCC a clear example of a boundary organization, spanning the supposed clearly delineable worlds of science and policy. Given the complex situation of satisfying the demands of both these worlds, delivering policy-relevant science in a situation of weak political consensus, we can assume that involved actors need to cooperate to achieve coherence, i.e. to establish boundary objects to support needed action. Before moving on to analyse how this was attempted in the case of the Bali Box, it is illustrative to consider how the IPCC has contributed to the formulation of policy targets based on quantified scientific knowledge.

2.2 A successful boundary object: The 2˚C target

The idea of a science-based, "top-down" approach to climate policy (e.g. Hare et al., 2010) builds on the ability of the IPCC to provide scientific input and legitimacy for the establishment of a series of quantified targets that link the global atmosphere to local climate policy. The Hague District Court ruling of June 2015 provides a useful example of how the IPCC is often invoked in public representations of such targets. In establishing the facts that form the basis for its ruling, the Court's first step is to establish the 2˚C target as a threshold for what constitutes dangerous climate change, quoting an IPCC statement that an increase of 1.5 to 2.5˚C above pre-industrial levels will pose "significant risks to many unique and threatened systems" (Hague District Court, 2015, p. 6). In a second step, the 2˚C target is translated into a maximum allowable concentration of greenhouse gases in the atmosphere, with reference to the emission scenarios assessed in the IPCC AR4 (Hague District Court, 2015, p. 7). Then a third step follows to establish the amount by which global greenhouse gas emissions would need to be reduced ("50-85% by 2050", according to AR4) in order not to exceed the maximum allowable concentration level.

The ruling thus shows how a series of interlinked, "science-based" targets are established in order to provide a firm basis for deciding climate policy, and – literally, in this case – to provide a judgement on it. The representation is perfectly in line with an understanding of science as an autonomous sphere with a one-directional relationship to policy. A closer look at how the targets presented in the ruling were developed, however, provides a somewhat different picture.

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[1] Description of the IPCC organization available on the IPCC website, at http://www.ipcc.ch/organization/organization.shtml (accessed 16.09.2015)

Randalls (2010) has shown how, in the 1960s and 1970s, "doubled CO_2 concentrations" was used as a basis for estimating the temperature response of increased greenhouse gas emissions. Some early models suggested 2˚C as a possible temperature rise in response to a doubling of CO_2. Based on this work, 2˚C was adopted as a "heuristic scenario" in cost-benefit analyses of climate change, and subsequently became the focus of scientific work to establish thresholds for dangerous climate change (Randalls, 2010, p. 599). The approach of defining such a threshold to guide policy was formalized with the 1992 adoption of the UNFCCC and its objective to "avoid dangerous anthropogenic interference with the climate system". Against this backdrop, the second assessment report from the IPCC, published in 1995, assessed the damages that would result from various increases of temperature, including 2˚C. This work influenced the EU to adopt 2°C as a reasonable target for what might constitute "dangerous anthropogenic interference" (Randalls 2010, p. 601). At the 2010 UN climate change meeting in Cancun, the target was formally adopted under the UNFCCC, and in 2015 it was enshrined in the Paris Agreement (Rajamani, 2016).

The 2˚C target is therefore best understood as an example of a rather successful boundary object – a "common point of reference (…) that allows networks of diverse actors to communicate and interact – albeit with varying motivations and objectives" (Geden and Beck, 2014, p. 747). In public debate, however, the 2˚C target is usually represented as a limit "formulated by scientists" or "justified by science" (Shaw, 2013) – as exemplified by the ruling of the Hague District Court. The hybrid character of the work that has gone into establishing the 2˚C target, the IPCC's role as a boundary organization in this work, and the fact that the target itself is a clear example of a boundary object, are all rendered invisible, while the organization and the object are perceived as representing "pure science".

2.3 Quantification as precision

The IPCC exemplifies a paradoxical desire to establish close cooperation between science and policy while at the same time maintaining a clear demarcation between independent spheres (Sundqvist et al., 2015). The boundary-work performed by the IPCC explicitly stresses the scientific side of this double ambition. This allows global climate policy targets to be presented as anchored in scientific authority in line with an ideal of science as an autonomous social institution. It should be clear, however, that the ambition to reduce complex issues of climatic risks to simplified single and double digit figures could not be driven by science alone.

Reducing complexity with the help of numbers has a long tradition in bureaucratic organizations, such as government authorities, which need quantifications to identify authoritative courses of action. Porter (2006) suggests that the use of numbers and quantification in such instances is not primarily about achieving correctness, but *precision*. The motivation behind using numbers has to do with mobilization and implementation, with making complex things governable and solvable (Porter, 1995). The 2°C target is a good example of a boundary object that works through precision. It is formulated in order to mobilize policy by means of scientific authority (and more generally objectivity), and to create a tight connection between science and policy by reducing complexity. As a boundary object it is interpreted differently by scientists and policymakers, allowing the former to focus on the uncertainties involved, while the latter may use it as a science-based target that delivers the precision needed for political mobilization.

In order for precise, science-based targets like the 2˚C target to have the required mobilizing effect, however, further translations are needed. In order for the Hague District Court to be able to make judgements on Dutch climate policy, for example, the targets established through the three-step translation process outlined above will need to be supplemented by a fourth step: transforming the numbers for long-term emission reduction on the global level into numbers for national emission reductions in the near term. The question facing the Court, in short, is this: how can a goal of reducing global emissions by 50–85% by 2050 be turned into a (science-based) target giving the precise amount of emission reductions required of the Netherlands over the next few years? Incidentally, this is the same question that was facing the nations assembled at the UNFCCC negotiations on a new international climate change agreement, from the Bali Conference in 2007 to Copenhagen in 2009. And this is where the Bali Box arrives on the scene.

3. The Bali Box and its numbers

Page 776 in the third volume of the IPCC AR4 contains a fact box entitled "Box 13.7. The range of the difference between emissions in 1990 and emission allowances in 2020/2050 for various GHG concentration levels for Annex I and non-Annex I countries as a group" (Gupta et al., 2007, p. 776). Despite its rather technical appearance, this box came to play a leading role in political negotiations on the highest international level. What was it about Box 13.7 that allowed it to generate such a level of political interest in a timespan of only a few months from the publication of the AR4?

Box 13.7 The range of the difference between emissions in 1990 and emission allowances in 2020/2050 for various GHG concentration levels for Annex I and non-Annex I countries as a group

Scenario category	Region	2020	2050
A-450 ppm CO_2-eq[b]	Annex I	-25% to -40%	-80% to -95%
	Non-Annex I	Substantial deviation from baseline in Latin America, Middle East, East Asia and Centrally-Planned Asia	Substantial deviation from baseline in all regions
B-550 ppm CO_2-eq	Annex I	-10% to -30%	-40% to -90%
	Non-Annex I	Deviation from baseline in Latin America and Middle East, East Asia	Deviation from baseline in most regions, especially in Latin America and Middle East
C-650 ppm CO_2-eq	Annex I	0% to -25%	-30% to -80%
	Non-Annex I	Baseline	Deviation from baseline in Latin America and Middle East, East Asia

Figure 1. Box 13.7 – The "Bali Box" (Gupta et al., 2007, p. 776)

The leftmost column of Box 13.7 is divided into three categories, representing three scenarios based on different concentrations of greenhouse gases in the atmosphere: 450, 550 and 650 ppm of CO_2 equivalent. In AR4, these scenarios were used to describe the implications of climate change at different levels of greenhouse gas emissions. In the UNFCCC negotiations, however, only the most stringent of the scenarios (450 ppm) received serious attention, as this was seen as the only scenario compatible with the EU's proposed target of keeping warming below 2°C. Countries in opposition to the EU's 2°C target were either calling for an even lower target or were reluctant to set a numerical target at all, which led to a general lack of interest in the higher-concentration scenarios.

Focusing on the 450 ppm scenario, what remains of Box 13.7 is a table of four squares, distinguished by the years 2020 and 2050, and by “Annex I” and “Non-Annex I”. The latter pair refers to the categories of countries under the UNFCCC, which defines Annex I countries as comprising what is usually understood as “the North” (that is, rich industrialized countries in Europe and North America, as well as Australia, New Zealand and Japan), while Non-Annex I refers to all other countries, or what is often termed “the South” or “the developing world”.

The categorization of countries into Annex I and Non-Annex I, in other words, follows the categorization into developed and developing countries that is institutionalized through the UNFCCC. On the basis of the principle of equity and “common but differentiated responsibility” enunciated in Article 3.1 of the UNFCCC, the Kyoto Protocol set out quantified emission reduction targets for Annex I countries, exempting Non-Annex I from such obligations. The 2007-09 negotiations on a new climate treaty were also influenced by this distinction. While the about 140 developing countries, organized in the negotiating bloc G77, pushed for continuous commitments for the industrialized North, the latter argued for emission cuts by the former as well.

When the IPCC AR4 was published, in the spring of 2007, the question of how to share the burden of necessary emission reductions among countries was already established as one of the most crucial issues in the negotiations (den Elzen and Höhne, 2008; Winkler et al., 2009). This issue also linked the climate negotiations to long-standing conflicts about historical power relations between the North and the South more generally, including colonialism and control of natural resources (Roberts and Parks, 2007).

Box 13.7, in short, attempts to translate the long-term global emission reductions that are necessary in order to reach the 2°C target, into targets that are more specified in time and space. It can be read as the IPCC’s response to the challenging question of burden sharing between the North and the South over the next ten years, and as a way to separate the question of distribution from the more general issue of historical injustices in North-South relationships. The answer that the Box provides to these complex questions is short and clear: by 2020, the North should reduce its emissions by 25–40% from 1990 levels, while the South should achieve a “substantial deviation from baseline”.

3.1 First stage: A scientific “fixed point”

A few months after the publication of the IPCC AR4, Box 13.7 became a main actor at the UNFCCC Climate Conference in Bali in December 2007 (den Elzen and Höhne, 2008, p. 250; Winkler et al., 2009, p. 635). The Conference marked the beginning of the negotiations for a new climate treaty, which, according to the plan, was to be finalized two years later at the Copenhagen Conference.

At the Bali Conference, the EU and the G77 were in agreement on the importance that the numbers in the upper-left corner of Box 13.7 (25–40% reduction in Annex I countries) serve as the foundation for the negotiations ahead of the Copenhagen Conference in 2009 (Winkler et al. 2009, p. 635). However, due to resistance from the United States no explicit reference was made to the numbers in Box 13.7 in the Bali decision, and as a compromise the Box was referenced in a footnote (den Elzen and Höhne, 2008, p. 250). Nevertheless, the media attention and political controversy surrounding the Bali meeting, and numbers of emission cuts discussed, placed Box 13.7 firmly on the agenda of the new two-year negotiation cycle, and following the negotiations it became widely known as the "Bali Box" (e.g. Tirpak and Gupta, 2008).

The proponents of including the numbers 25–40% in the Bali decision acted from slightly different motivations. The EU had already committed to reducing its emissions by 20% by 2020, with the possibility of increasing this commitment to 30% if other countries made comparable contributions. They therefore saw themselves as already being within the range of the Bali Box, and wanted to push other Northern countries (notably the US) to commit to similar reductions. The G77 group of Southern countries, on the other hand, wanted to see as deep commitments as possible from all Northern countries, and the numbers from the Bali Box provided an IPCC-sanctioned basis on which to formulate a specific demand. A third group of actors, the environmental NGOs, were also pushing for the numbers of the Bali Box, acting from a combination of the motivations of the EU and the G77 (Lahn, 2013).

A common denominator among all these actors was that "the *science-based range* [of Box 13.7] provides *a fixed point*", from which to derive commitments for individual Annex I countries (Winkler et al. 2009, p. 636, emphasis added). Two things therefore seem to have made the numbers 25–40% in the Bali Box so valuable in the initial stage of negotiations. Firstly, they were seen as *science-based*. Drawing on the credibility that the IPCC reports already enjoyed within the UNFCCC negotiations, the numbers came to represent "what science says", or, more precisely, what "the IPCC states" that Northern countries "need" to do (Baer, 2008, p. 19; Höhne and Ellerman, 2008, p. ii). Secondly, the emission reductions in Annex I countries were *quantified*, and thus were taken to be uniform and more easily applied in a political setting (a "fixed point"), as opposed to the more multivalent and ambiguous call for a "substantial deviation from baseline" in the emissions of Non-Annex I countries.

Underlying both of these reasons for the prominence of the 25–40% range is the fact that the Bali Box was essentially treated as a *black box* – its inner workings and historical origins were neither understood nor perceived to be relevant by many of the actors seeking to enrol it in their political projects. To these actors, the opaque character of the Box made it all the more useful; the scientifically justified and "IPCC approved" numbers provided the fixed point that they needed in order to "move the world" during the two years leading up to COP 15.

3.2 Second stage: Opening the black box

Shortly after the Bali Conference, two contributors to the IPCC report, Michel den Elzen and Niklas Höhne, published an article in the journal *Climatic Change*. Identifying themselves as "the authors of Box 13.7", they state that the aim of the paper is to "provide more details" on how the numbers in the Box were derived (den Elzen and Höhne, 2008, p. 250). In addition to providing such details, however, the paper also sets out to quantify what a "substantial deviation from baseline" in Non-Annex I countries might mean. It concludes that if Annex I countries reduce their emissions by 25–40% from 1990 levels by 2020, the corresponding figure for Non-Annex I countries would be a deviation of 15–30% from their baseline emissions. Thus, in their paper, den Elzen and Höhne in effect proposed the range "15–30%" as a natural Southern counterpart to the Northern range of "25–40%", thereby establishing a science-based "fixed point" for emission reductions in the South as a logical continuation of the development of the Bali Box.

The paper presents the range of 15–30 % not as adding new information to that already contained in Box 13.7, but simply as quantifying what has already been implicitly assumed: If global emissions are to be reduced by a given amount, and the Northern countries reduce their emissions by 25–40% in order to achieve this, establishing the "remainder" to be reduced by the Southern countries appears to be a matter of simple arithmetic (Winkler et al., 2009). This however raises the question of why these numbers were not included in Box 13.7 of the IPCC AR4 in the first place. It is natural to think that the reason for not quantifying the commitments of the Non-Annex I countries in AR4 was to stay within the existing institutional framework of the UNFCCC and the Kyoto Protocol, which formulates quantitative commitments of the North, while providing more general and qualitative commitments for the South.

In this way, whereas the IPCC report tacitly adapted its scientific content to the established practice in international climate policy, the new numbers presented by den Elzen and Höhne (2008) can be understood as a challenge to the established political order. Moreover, it was a challenge that fitted well with the political positions of many countries in the North, and especially with the position of the EU, in the UNFCCC negotiations. And indeed, European countries were quick to incorporate the numbers from den Elzen and Höhne's paper in policy documents. In March 2009, the range "15–30%" was established in the EU position paper for the upcoming COP 15 in Copenhagen, on par with the numbers in the original Bali Box, as what the EU expected countries in the South to commit to (Winkler et al., 2009, p. 637).

Other actors in the UNFCCC negotiations, however, met the new numbers with scepticism and outright hostility. At a technical briefing for UNFCCC negotiators in March 2009, a number of questions put to Niklas Höhne from Southern countries like India and Bolivia indicated that these countries did not readily recognize his new numbers as a "science-based fixed point".[2] On the contrary, suspicion about the numbers for Non-Annex I countries led to both the temporal and spatial dimension of the Bali Box being challenged. Questions were asked about the previously more widely accepted numbers for Annex I countries. What was the basis for arriving at this particular division of emission reductions between Annex I and Non-Annex I countries? And what is the scientific rationale for choosing 2020 as the specific year for achieving near-term emission reductions? Questions were even asked regarding Höhne's personal role and motivation in the process of arriving at these particular numbers.

These critical questions challenged the scientific credibility of the Bali Box as well as the more recent range of 15–30% for Non-Annex I countries. And the challenge came mainly from developing countries – the same group that had previously used the Bali Box to argue for 25–40% emission reductions in the North. This complete turnaround in attitudes toward the Bali Box must be understood in relation to den Elzen and Höhne's new paper. The new numbers "15–30%" serve to highlight the fact that the original numbers "25–40%" implicitly required substantial emission reductions from developing countries too (Baer 2008, p. 20). From being a scientific pusher for quantified obligations for Northern countries, the Bali Box was transformed into a device for establishing a specific distribution of emission reductions between the North and the South. For the South, this raised a number of questions. How did these researchers arrive at this specific distribution? How did their distribution match the preferred distributional principles of Southern countries? And what made the distribution

[2] The description of this meeting is based on personal observations and video recordings of the technical briefing held on 20 March 2009, at the UNFCCC intersessional meeting in Bonn, Germany. Video recordings are available at http://unfccc.int/meetings/bonn_mar_2009/meeting/6312/php/view/webcasts.php (accessed 22.11.2015)

proposed in the Bali Box more "scientific" than other proposals? Such questions in turn led to a re-examination of the principles and assumptions underlying the numbers that had so far been black-boxed.

As the paper by den Elzen and Höhne, (2008) as well as subsequent commentary (Baer, 2008; Winkler et al., 2009) made clear, the methodology of the Bali Box was not one of choosing among the many existing approaches to equitable burden sharing. Rather, it was based on compiling an *average range* of emission reductions that would be expected from different groups of countries under a wide range of different burden-sharing proposals.

Actors in the UNFCCC negotiations have proposed a range of criteria for how to achieve fair sharing of the burden associated with reducing emissions, including historical responsibility for past emissions; worldwide convergence of emissions per capita; and a sharing of responsibility based on marginal abatement costs, gross national income, etc. (e.g., Okereke, 2010). A number of studies have calculated the distribution of emissions reductions under one or more of the proposed principles. The calculations underlying Box 13.7 were based on an assembly of such studies, chosen according to den Elzen and Höhne's expert judgement. Thus, the numbers they presented were based on a synthesis of a set of highly divergent – and to some extent mutually exclusive – philosophical principles and policy proposals (den Elzen and Höhne, 2008, p. 257). Among these principles, some had been strongly opposed by actors in the UNFCCC negotiations. Others were excluded as "outliers" on the basis that they were considered politically unrealistic (Baer, 2008, p. 20; den Elzen and Höhne, 2008, p. 254).

Against this background, it is clear that the Bali Box should be understood as a *boundary object* – an attempt to stabilize a hybrid assemblage of scientific and political elements, and an effort to make communication and agreements possible across what is understood as sharp boundaries between science and politics, and between social worlds with different visions of fairness. Initially, the Bali Box seemed rather successful in these efforts. The success was however based not on an acknowledgement of its hybrid character, but rather on a belief that the numbers in the Box were an expression of "pure science". As the assumptions and underlying choices of den Elzen and Höhne's approach were unpacked by actors in the negotiations, this view was challenged. Instead of a scientifically fixed point that held the potential to resolve the complex issue of equity between the North and the South, the new numbers presented by den Elzen and Höhne became a source of controversy, calling into question the scientific credibility of what had previously been seen as an expression of "what science tells us".

Interestingly, the political implications of the Bali Box only received attention when the numbers challenged the established political and institutional framework for international climate politics. While they were initially accepted and understood to be science-based among many actors in the North and the South alike, the supplemental numbers in den Elzen and Höhne's new paper quickly came to be understood as political – especially in developing countries – because they went beyond politically agreed principles of the UNFCCC and the Kyoto Protocol. In other words, it seems that scientists' arguments are perceived to be more "scientific" when they are tacitly adapted to established political and institutional principles, while disregarding such principles makes them more likely to be perceived as "political".

3.3 Third stage: The pendulum swings

The re-opening of the Bali Box led to intensified boundary work by the IPCC in order to reestablish clear boundaries between science and politics. The scientists previously involved in the AR4 were undoubtedly aware of the controversy that the numbers of Box 13.7 sparked in the UNFCCC negotiations. When the AR5 was published in 2014, it contained no similar box or numbers that updated or expanded on the Bali Box – despite widespread expectations that it would (Knopf and Geden, 2014). Instead, the Report's introductory summary made a general statement that many aspects of climate policy "involve value judgements and ethical considerations" (IPCC, 2014), placing (among other things) the distribution of responsibility for emission reductions in the category of policy choices requiring such considerations. In line with this approach, the Report presented a plurality of possible quantification frameworks, without attempting to synthesize them (Clarke et al., 2014, pp. 456-460)

The absence of a new Bali Box or similar numbers in the AR5 may be understood as an implicit response to the controversy that arose around the Bali Box following den Elzen and Höhne's attempt to expand its reach. The controversy had the effect of changing the Box from "pure science" into "pure politics". In order to protect the scientific credentials of the IPCC and reassert a clear boundary between science and policy, the authors of the AR5 responded by locating the Box and its numbers outside the realm of science. The underlying "philosophy of the new IPCC report" (Knopf and Geden, 2014), in other words, is that scientists may describe the principles and consequences of different burden-sharing approaches, but not decide on them. Science may inform value judgements, but not attempt to make them. This new "philosophy" suggests a "division of labor between science and policy" that is much clearer in the AR5 than in the AR4 (Knopf and Geden, 2014).

The retreat of the IPCC may be seen as a third stage in the story of the Bali Box, illustrated with a pendulum swinging back and forth. In the first stage, the Box and its numbers were perceived as science-based. When, in the second stage, the tight coupling between science and political choices became clearly visible, the Box was dismissed by important actors as unacceptable (European) politics. This controversy over the numbers led the IPCC, in the third stage, to place the numbers outside the terrain of objects that the IPCC as a scientific body should summarize in its Fifth Assessment Report. The consequence was a retreat by the IPCC, their "new philosophy" being a form of boundary work that protects scientific authority by reducing its territory (Jasanoff, 1990; Sundqvist, 2011). The IPCC seems to have abandoned attempts to establish a scientifically based "fixed point" for equitable sharing of emission reductions between the North and the South, transferring this discussion from the realm of science to the realm of politics.

4. Conclusions: The Bali Box and the Climate Debate

When the pendulum swings from "pure science" to "pure politics" in how the Bali Box is understood, it follows a logic in public understandings of science that Collins and Pinch (1993) call "flip-flop thinking". According to this understanding, if science does not deliver certainty, it delivers nothing; science becomes "all good or all bad" (Collins and Pinch, 1993, pp. 1, 142). With the ambition to clearly demarcate science from politics, flip-flops are hard to avoid: As soon as scientific results are found to be influenced by political reasoning, they are no longer pure and independent, and therefore easily dismissed. Climate science is to a great extent ensnared by a flip-flop logic. The story of the Bali Box is one example. Another is found in the criticism from climate sceptics, who, by pointing to any kind of political influence on climate science – and there are of course many – are able to compromise its "purity" (Wynne, 2010; Goeminne, 2012). A consequence of building climate policy on a view of pure science as located outside of the political realm, therefore, is that it increases vulnerability, in the sense that any contact between science and politics risks overturning the ambition to establish a policy “based on science”. This is one lesson from the story of the Bali Box.

Another lesson concerns the black boxes that science is able to construct and maintain. The good thing about a black box is that discussions, negotiations, controversies and uncertainties are settled, enabling us to act based on a certainty that things work as they should. The downside is that it shortcuts political debate. In the first phase of the story of the Bali Box, the Box and its numbers were taken for granted, and could therefore be used as a basis for establishing national emission reduction targets – primarily in Europe. However, when developing countries raised questions about these numbers and started asking for targets based on principles other than those summarized in den Elzen and Höhne’s work, European countries were poorly equipped to enter this discussion. Environmental groups, which could have been better placed to participate, were also engaged in supporting the IPCC as an organization delivering “pure” science. As a black box, the Bali Box offered a ready-made quantified solution to a controversial problem. The consequence of black-boxing, however, was a weaker understanding of the underlying principles and political conflicts. The story of the Bali Box illustrates that separating science from policy and politics results in a poor understanding of the questions that are needed for robust political decision-making.

As shown above, the Bali Box is not the result of science alone. It is a hybrid product, a boundary object that for a period of time gathered a range of actors who for different reasons supported its numbers. The fact that the Box ultimately failed to hold together this assemblage of actors and motivations can be understood as a result of problems arising at two different levels. The first is the *representational level*, where the ambition of many actors to represent the numbers as exclusively “science-based” led to the kind of flip-flop thinking outlined above. Scientific knowledge has been of great importance in establishing the numbers of the Bali Box, but so has value judgements and political considerations. The problem on this level arises from the IPCC’s failure to acknowledge this hybridity, instead allowing the pendulum to swing back from pure politics to pure science, re-establishing clear boundaries in an attempt to rescue scientific authority from political influence.

On the other hand, it seems unlikely that simply acknowledging the hybrid character of the IPCC, the 2˚C target and the Bali Box would increase the chances of achieving the simplification and precision that the Bali Box set out to achieve. Taking the notion of boundary objects seriously, as a tool that can help us go beyond endless discussions about what is science and what is politics, the final lesson we draw from the story of the Bali Box is the need to focus on the Box itself, what it did, and what actors were able to achieve by developing and using it.

The expanded Bali Box tried to reduce a complex set of questions – about a global temperature target, a maximum concentration of greenhouse gases in the atmosphere, and a distribution of emission reductions among regions in order to reach these maximum levels – to a few numbers. This is an example of simplifying, categorizing, standardizing, and quantifying complex issues in order to create the basic coherence that is required for cooperation in the absence of consensus. As such, what should be of interest both for climate practitioners and social science analysts is not how the boundary is drawn between science and policy, but how the Bali Box first succeeded at establishing a “good enough” road map across different social worlds, but then failed when the “residual categories” – the anomalies that did not fit in – grew stronger and called the existing categories into question. In other words, following Star (2010, p. 609), we need to examine how the Box aimed to solve problems *and* created new ones.

This leads us to the second level at which problems arose in the story of the Bali Box, that is, the *process level*, or how the content of the Box was produced. Using Star's terminology, it is easy to identify "residual categories" that ultimately caused the extended Bali Box to fail. The process by which two European researchers created a set of numbers to handle an issue that has been controversial for decades – namely how to share the mitigation effort between North and South – did not gain acceptance. This is not to say that hybrid numbers established in a different way, through a different process, could not have led to more widely accepted solutions. An obvious lesson to draw from the story of the Bali Box is that discussions on equitable effort sharing between countries need to take into account the power relations between nations and regions – relations that to a certain extent have been reinforced by the dominant role of science and scientists in climate work (Lahsen, 2007; Miller, 2004; see also Corbera et al., 2016). Scientific numbers that deal with issues of distribution in this context may have a higher chance of achieving status as "good enough" if they are developed in a more inclusive and participatory manner than was the case with the Bali Box.

The ruling of the Hague District Court in June 2015 shows that the numbers of the Bali Box to a certain extent continue to play a role in shaping ideas about equity in climate change mitigation – even after the Box became contested and lost its influential role in international climate politics. This points to the need for numbers and other tools that allow for continued engagement with the questions that the Bali Box sought to answer. As the failed attempt to create a "top down" climate change agreement in Copenhagen has been followed by the adoption the Paris Agreement's "bottom up" structure for distributing responsibilities between countries (Rajamani, 2016; Hare et al., 2010), the role of quantification in discussions of North-South equity is likely to change – but not necessarily in terms of decreasing relevance. The process established by the Paris Agreement to review the ambitiousness of national contributions is explicitly said to be carried out "in the light of equity and the best available science" – opening the door to a deepened international dialogue on equitable effort-sharing (Rajamani, 2016, p. 504). This calls for more, not less, scholarly engagement with the questions of the Bali Box (cf. Klinsky et al., 2016) – as well as for a more reflexive approach that enables robust discussion, rather than black-boxing, of the scientific and political elements that these questions bring to the fore.

Numbers and quantifications may often work as boundary objects, creating meeting points between science and policy (Sundqvist et al. 2002) where actors jointly try to manage complex problems and challenges. But for this to happen, we need to move beyond the idea of strong demarcations that dominates the climate field today. To find broadly accepted science-based solutions to the problem of equitable effort-sharing in climate change mitigation, a better understanding is needed of the role of science in the complex terrain of world politics and North/South power relations, and not least of how quantifications and numbers can find their proper place and thus become useful in facilitating the necessary cooperation.

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