Leiden Journal of International Law (2024), **37**, 139–166
doi:10.1017/S0922156523000559

ORIGINAL ARTICLE

INTERNATIONAL LAW AND PRACTICE

Science, epistemology and legitimacy in environmental disputes – The epistemically legitimate judicial argumentative space

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Abstract
This article maps the elements of the epistemically legitimate argumentative space of judges in scientific disputes, where scientific facts and arguments intrude into the legally relevant aspects of the legal controversy. The article distinguishes four main forms of legitimate hybrid reasoning styles. It identifies the epistemic risks threatening the legitimacy of decisions in light of the corresponding limits of the epistemically legitimate argumentative space. The article concludes by discussing the parameters which help judges to select the appropriate reasoning style in particular cases, such as the judicial institution's epistemic capacities, practical feasibility, and the role science plays in the fabric of legal rules.

Keywords: environmental adjudication; epistemic legitimacy; judicial reasoning style; science; scientific disputes

1. Introduction

The omnipresence of scientific evidence and science-based arguments is the hallmark of environmental disputes that are decided by various international jurisdictions. However, there is no judicial consensus on the extent and ways in which scientific knowledge should be integrated into the adjudicatory analysis. Despite the central profile of scientific knowledge in disputes featuring environmental components,[1] international forums attach markedly divergent roles and standing to scientific arguments in their inquiry.[2] As a result, scientific knowledge permeates judicial reasoning to a surprisingly diverse extent. Even though the parties' pleadings normally rely heavily on scientific evidence and arguments concerning issues such as environmental liability or the non-arbitrary nature of their risk assessment decisions, adjudicatory findings on these matters do not necessarily display scientific rationality.

Science enters the courtroom as an extra-legal cognitive authority, about which judges typically lack in-depth knowledge and expertise. It therefore comes as no surprise that conflicting scientific

*The author is grateful to the editors and the two anonymous reviewers for their insightful suggestions. For any remaining errors, the usual disclaimer applies. The ideas expressed in this article draw on the author's book entitled *Science and Judicial Reasoning – The Legitimacy of International Environmental Adjudication* (2021).

[1]Environmental disputes are defined here as disputes with environmental components, see P. M. Dupuy and J. E. Vinuales, *International Environmental Law* (2018), 300.

[2]For recent overviews on how science is treated by international courts see K. Sulyok, *Science and Judicial Reasoning - The Legitimacy of International Environmental Adjudication* (2021); C. Ragni, *Scienza, Diritto e Giustizia Internazionale* (2020).

input is 'the purgatory of judges'.[3] The presence of cognitively authoritative knowledge claims indeed gives rise to challenges for international courts with respect to the whole spectrum of the adjudicatory process. More precisely, it poses challenges for conducting scientific fact-finding that fits with the epistemic capacities of adjudicators while also meeting the expectations of litigants, for preserving the judicial monopoly over dispute resolution, and also for crafting a judgment that is seen by the wider public as non-arbitrary and thorough in the light of pertinent scientific knowledge. Earlier scholarly commentary has discussed the hardships caused by science with respect to evidentiary techniques[4] and the depth of judicial review.[5] This article takes this line of inquiry further by providing a fine-grained analysis of how the presence of cognitively authoritative scientific arguments in litigation complicates making convincing and legitimate judicial findings.

Crafting a reasoning is the essence of judicial discretion and authority. Providing explicit justifications for the decision reached is also an obligation for courts, as it guards against arbitrary decision-making.[6] The exact modalities in which judges comply with such a duty to give reasons have direct implications for claiming persuasive force and legitimacy for their rulings.[7] This is especially true in disputes where the legal controversy has marked scientific dimensions.

The main concern of this article therefore lies in how the presence of cognitively authoritative scientific knowledge impacts the modalities of crafting convincing and (epistemically) legitimate judgments. Epistemic legitimacy requires the judicial reasoning to conform to or, at a minimum, respect the cognitive authority of science in their inquiry.[8] This specific understanding of legitimacy warns that judicial findings running counter to scientific truths will appear arbitrary and will lose their persuasive force. Legal philosophy warns that making epistemically non-arbitrary choices is a prerequisite for making legitimate judgments in scientific disputes.[9] Despite its key role in shaping the convincing force of judgments, with some notable exceptions,[10] the impact of science's epistemic authority on the legitimacy of international adjudication,[11] and that of environmental disputes in particular,[12] has been underappreciated in the literature. Judicial

[3]*Pulp Mills on the River Uruguay (Argentina v. Uruguay)*, Judgment of 20 April 2010, [2010] ICJ Rep. 14, para. 148 (Judge Cançado Trindade, Separate Opinion).

[4]L. Boisson de Chazournes et al., 'One Size Does Not Fit All—Uses of Experts before International Courts and Tribunals: An Insight into the Practice', (2018) 9 *Journal of International Dispute Settlement* 477; M. M. Mbengue, 'Scientific Fact-Finding at the International Court of Justice: An Appraisal in the Aftermath of the Whaling Case', (2016) 29 *Leiden Journal of International Law* 529; L. Malintoppi, 'Fact Finding and Evidence Before the International Court of Justice (Notably in Scientific-Related Disputes)', (2016) 7 *Journal of International Dispute Settlement* 421.

[5]L. Gruszczynski and V. Vadi, 'Standard of Review and Scientific Evidence in WTO Law and International Investment Arbitration: Converging Parallels?', in L. Gruszczynski and W. Werner (eds.), *Deference in International Courts and Tribunals: Standard of Review and Margin of Appreciation* (2014), 152.

[6]D. Dwyer, *The Judicial Assessment of Expert Evidence* (2008), 39; R. B. Stewart, 'Remedying Disregard in Global Regulatory Governance: Accountability, Participation, and Responsiveness', (2014) 108 *American Journal of International Law* 211, at 252.

[7]I. Griss, 'How Judges Think: Judicial Reasoning in Tort Cases from a Comparative Perspective', (2013) 4 *Journal of European Tort Law* 247, at 250.

[8]C. A. Thomas, 'Of Facts and Phantoms: Economics, Epistemic Legitimacy, and WTO Dispute Settlement', (2011) 14 *Journal of International Economic Law* 295.

[9]S. Brewer,'Scientific Expert Testimony and Intellectual Due Process', (1998) 107 *Yale Law Journal* 1535, 1677.

[10]Thomas, *supra* note 8, for a study on several international decisions demonstrating legal, scientific and intuitive rationality see J. D'Aspremont and M. M. Mbengue, 'Strategies of Engagement with Scientific Fact-Finding in International Adjudication', (2014) 5 *Journal of International Dispute Settlement* 240. The present article provides a more detailed taxonomy of the reasoning styles, differentiating a hybrid reasoning method. It also provides a systematic overview of the factors that assist international courts and tribunals in crafting epistemically legitimate reasoning under different factual circumstances. While D'Aspremont and Mbengue examine epistemic problems as part of courts' various fact-finding strategies, the present study adopts a broader approach and classifies all types of judicial tools according to their underlining rationality, even those outside the scope of fact-finding techniques (such as different causal doctrines or standards of review).

[11]N. Grossman et al. (eds.), *Legitimacy and International Courts* (2018); K. J. Alter, L. R. Helfer and M. R. Madsen (eds.), *International Courts Authority* (2018).

[12]C. Voigt (ed.), *International Judicial Practice on the Environment - Questions of Legitimacy* (2019).

decisions also appear to be oblivious to the dangers of epistemically arbitrary argumentation, leading to *ad hoc* approaches to treating scientific authority in the judicial assessments.

This article will address some fundamental epistemological questions and map the epistemically legitimate methods of argumentation to reflect on science in the judicial reasoning. The main queries are whether judges can (justifiably, hence, legitimately) reason *using* scientific knowledge, and if so, under what circumstances; and whether a non-scientist adjudicator can (justifiably, hence, legitimately) reason *against* scientific rationality in a judgment. Whereas previous scholarly works typically appraised the role of science in specialized regimes of international law,[13] or with regard to the practice of a particular international court or tribunal,[14] this study will provide a broader, cross-jurisdictional overview of how science may shape the judicial reasoning in epistemically legitimate ways.

A key component of the judicial task lies in translating scientifically legitimate expert input into legally legitimate judicial findings, in other words, authoritative statements that are seen as a persuasive outcome of the adjudicatory process. However, science has its own rules governing the (scientific) legitimacy of expert findings, set forth by accepted conventions of the scientific community (often referred to as the scientific method)[15] for producing results that are deemed scientifically valid and reliable (and hence legitimate) in the process of scientific knowledge production and as part of the scientific discourse. Even though natural sciences are often perceived (or projected)[16] as belonging to a strictly objective realm, where normative considerations (such as cultural conventions and personal subjective beliefs) have no role to play in knowledge formation, ample theoretical insights and empirical studies offered by science and technology studies suggest otherwise. They point out a number of social conditions, including the power relations embedded in peer review and funding processes,[17] and the prescriptive function and psychological pressure of the reigning scientific paradigm,[18] which suggest that scientists also use agreed rules and conventions to validate acceptable ('legitimate') knowledge claims from a scientific point of view.

A problematic aspect of such a translation exercise is that legally trained judges may find even those reasoning techniques persuasive ways to resolving scientific disputes that require little or no interaction with scientific facts. However, as will be argued here, there is a limit to which scientific knowledge can be replaced by purely non-scientific reasoning in a legitimate way, which is marked by the concept of epistemic legitimacy. To craft an epistemically sound judicial reasoning in science-heavy disputes, the imperative of epistemic legitimacy must be observed. In the judicial

[13]H. Woker, 'The Law-Science Interface in the Arctic: Science and the Law of the Sea', (2022) 13 *The Yearbook of Polar Law Online* 341; M. M. Mbengue and Rukmini Das, *Use of Experts in International Freshwater Disputes* (2019).

[14]A. Ridell, 'Scientific Evidence in the International Court of Justice - Problems and Possibilities', (2009) 20 *Finnish Yearbook of International Law* 229; A. Press, 'Science in the Court! The Role of Science in "Whaling in the Antarctic"', in M. Fitzmaurice and D. Tamada (eds.), *Whaling in the Antarctic: Significance and Implications of the ICJ Judgment* (2016), 346; J. Pauwelyn, 'Expert Advice in WTO Dispute Settlement', in G. A. Bermann and P. C. Mavroidis (eds.), *Trade and Human Health and Safety* (2006), 235; D. Palmeter, 'The WTO Standard of Review in Health and Safety Disputes', in G. A. Bermann and P. C. Mavroidis (eds.), *Trade and Human Health and Safety* (2006), 224; D. Anderson, 'Scientific Evidence in Cases under Part XV of the LOSC', in M. H. Nordquist et al. (eds.), *Law, Science and Ocean Management* (2007), 503; T. Treves, 'Law and Science in the Interpretation of the Law of the Sea Convention: Article 76 Between the Law of the Sea Tribunal and the Commission on the Limits of the Continental Shelf', (2012) 3 *Journal of International Dispute Settlement* 483.

[15]J. Scott Armstrong and K. C. Green, *The Scientific Method A Guide to Finding Useful Knowledge* (2022).

[16]More on the cultural practices that project a picture of scientistic research, which is insulated from the critics of the lay public while produces purportedly value neutral, objective facts see B. Latour, 'Give Me a Laboratory and I Will Raise the World', in K. Knorr-Cetina and M. Mulkay (eds.), *Science Observed: Perspectives on the Social Study of Science* (1983), 141.

[17]S. Krimsky, 'Publication Bias, Data Ownership, and the Funding Effect in Science: Threats to the Integrity of Biomedical Research', in W. Wagner and R. Steinzor (eds.), *Rescuing Science from Politics: Regulation and the Distortion of Scientific Research* (2006), 61.

[18]T. Gieryn, 'Boundaries of Science', in S. Jasanoff, G. E. Markle and T. Pinch (eds.), *Handbook of Science and Technology Studies* (1995), 393, at 402, where he points out that 'Eventually, a new paradigm attracts most practitioners and wins, not by convincing scientists with its superior logic or empirical evidence but through a non-rational gestalt-switch conversion grounded more in the psychology of perception and the sociology of commitment than in methodology.'

quest for epistemically legitimate decisions, scientific and legal legitimacy inevitably interact with one another. This article explores the questions arising from such an interaction, namely whether scientific legitimacy is a prerequisite for legal legitimacy, or whether legally legitimate decisions can be crafted irrespective of, or, in some extreme cases, even against scientific legitimacy.

As to its methodology, the article provides a typology of judicial argumentative techniques with which international courts reflect on scientific knowledge. The taxonomy is anchored to some concrete examples drawn from the case-practice of international forums hearing environmental disputes under various specialized regimes of international law. An exhaustive analysis of the practice of relevant forums is well beyond the short confines of this article. Instead, select case law will illustrate the techniques that judges typically apply in science-intensive environmental and public health disputes. As a result, the analysis features decisions that are comparable, to the extent possible, in terms of their underlying law, procedural rules of adjudication and the legal culture of international dispute resolution. [19] The focus will be on environmental disputes, as this field has generated an abundant case law, where international forums had to reflect on pleadings that tend to be characteristically science-heavy. All this makes environmental jurisprudence a rich and relatively homogenous testing ground for analysing judicial reasoning techniques in a science-heavy context.

The findings of this research, however, aspire to be relevant beyond the narrow confines of the past and currently pending environmental lawsuits.[20] It seeks to offer insights into how judicial decision-makers should craft epistemically more robust analyses in diverse legal settings, where any types of scientific knowledge (from the natural, medical, or social sciences) inevitably pervade the underlying facts or the substantive law at various stages of the judicial process. Respective legal fields may range from international criminal law to human rights law, humanitarian law, or the law of the sea to name a few obvious examples. There is a particularly acute need to factor in and reflect on scientific information in climate litigation. These proceedings have recently reached international forums too,[21] which could particularly benefit from the judicial good practices of environmental jurisprudence regarding crafting epistemically legitimate reasoning, especially because environmental jurisprudence is a typical point of reference in climate change related claims.[22]

The analysis proceeds as follows. Section 2 discusses the epistemic nature of scientific authority and details the epistemic complexities arising from the interaction of scientific and legal authority in the courtroom. Section 3 maps the limits of epistemically legitimate argumentative space in Subsection 3.1, and discusses the epistemic risks that may, if applied, threaten the legitimacy of judicial reasoning. Subsection 3.2 depicts the pathways for crafting legitimate reasoning that may

[19]Even though international forums decide disputes under various substantive branches of international law, these disputes are still comparable, in as much as they are all rooted in public international law. While their exact procedural rules may vary, they still share some fundamental similarities that are absent in domestic adjudication and which are rooted in the fact that one of the litigants is a sovereign. Finally, even though the college of international judges is not homogeneous, their education, experience and expertise in international law set them apart from domestic judges. See L. Swigart and D. Terris, 'Who Are International Judges?', in C. Romano, K. J. Alter and Y. Shany (eds.), *The Oxford Handbook of International Adjudication* (2014), 620, at 621–2; F. Baetens, *Identity and Diversity on the International Bench - Who Is the Judge?* (2020).

[20]See, e.g., the first inter-state arbitration under the Bern Convention on the Conservation of European Wildlife and Natural Habitats filed by Azerbaijan on 18 January 2023 against Armenia. Azerbaijan argues that Armenia has violated its obligations to maintain populations of all wild flora and fauna, during the nearly 30 years of the illegal occupation of its territories.

[21]See Advisory proceedings currently pending before the ITLOS (Request for an Advisory Opinion submitted by the Commission of Small Island States on Climate Change and International Law submitted on 12 December 2022) and the Inter-American Court of Human Rights (Request for an advisory opinion on the scope of the state obligations for responding to the climate emergency, filed by Chile and Colombia on 9 January 2023). An Advisory Opinion has also been requested by the UN GA from the International Court of Justice on 29 March 2023 (UNGA Resolution A/77/L.58).

[22]See the pleadings of the applicants in cases pending before the European Court of Human Rights, where they reinterpret the Court's previous environmental case law regarding Arts. 2 and 8 of the European Convention on Human Rights in the context of climate change, in *KlimaSeniorinnen v. Switzerland* (no. 53600/20), *Carême v. France* (no. 7189/21), *Duarte Agostinho and Others v. Portugal and Others* (no. 39371/20).

equally be built on scientific as on non-scientific epistemic rationality. Section 4 analyses the different argumentative styles of international courts by identifying scientific, legal, hybrid and intuitive types of reasoning, illustrated with concrete examples from international environmental jurisprudence. This section distinguishes epistemically legitimate and illegitimate forms of reasoning with respect to each of the argumentative styles. Finally, Section 5 offers the parameters that judges ought to consider when selecting the appropriate type of rationality to appeal to in their justification. Section 6 serves as the epilogue.

2. Epistemic complexities triggered by scientific authority entering the courtroom

When scientific authority enters a litigious context, via expert evidence or in the form of less formalized science-based legal arguments by the parties, adjudicators face idiosyncratic epistemic dilemmas. Due to these epistemic hardships, scientific input is not amenable to straightforward judicial appraisal, which can be traced back to the Janus-faced character of scientific knowledge: while science can only provide ambiguous and uncertain answers, as scientific knowledge is inevitably burdened with scientific uncertainty, it is nevertheless generally regarded as a highly authoritative method of understanding the factual realities of natural processes. Science therefore enters the courtroom as an infinitely uncertain yet persuasive cognitive authority. The following will explore the finer nature of science's epistemic character and the ways in which it shapes the adjudicatory dynamics in scientific disputes.

Scientific uncertainty means that scientific research can only provide probabilistic results, as some uncertainty inevitably surrounds the precise value of a given parameter, even despite constant scientific progress. The problem of uncertainty in the sciences therefore runs deeper than a mere insufficiency of scientific knowledge or the contradictory nature of expert submissions. Scientific uncertainty has heterogenous sources, such as modelling uncertainty,[23] the extremely high complexity of environmental systems,[24] errors of the measurement device,[25] and the subjectivity inherent in extrapolating time series or limited data points.[26] Some of these sources can be reduced, or even eliminated, whereas others cannot be precluded from the process of scientific knowledge production. A further notable point is that uncertainty in the sciences plays fundamentally divergent roles in the scientific and the legal realm. Whereas natural scientists treat inherent uncertainty as part of the normal parameters of their discipline, law's 'idolatry of certainty'[27] often poses an obstacle for legal adjudicators to *ascertain* the factual bases of their legal conclusions.

At the same time, scientific results carry strong cognitive authority, which is seen as a prerequisite for making rational and unbiased decisions.[28] The authoritative nature of scientific knowledge shapes the dynamics of litigation. Scientific disputes essentially boil down to a contest between litigants for appealing to science's cognitive supremacy, where the prevailing party will be able to label its position as 'reliable science', which confers a highly authoritative nature on its factual narrative. At the same time, scientific knowledge can also be abused when it serves as a disguise for litigants' non-scientific motivations, such as protectionism[29] or discriminatory

[23]H. M. Regan, M. Colyvan and M. A. Burgman, 'A Taxonomy and Treatment of Uncertainty for Ecology and Conservation Biology', (2002) 12 *Ecological Applications* 618, at 620.

[24]P. Yodzis, 'Must Top Predators Be Culled for the Sake of Fisheries?', (2001) 16 *Trends in Ecology & Evolution* 78, at 80.

[25]See Regan, Colyvan and Burgman, *supra* note 23, at 619.

[26]J. O'Reilly et al., 'Characterizing Uncertainty in Expert Assessments: Ozone Depletion and the West Antarctic Ice Sheet: Characterizing Uncertainty in Expert Assessments', (2011) 2 *Wiley Interdisciplinary Reviews: Climate Change* 728, at 737.

[27]E. W. Thomas, *The Judicial Process - Realism, Pragmatism, Practical Reasoning and Principles* (2005), 108.

[28]W. G. Werner, 'The Politics of Expertise: Applying Paradoxes of Scientific Expertise to International Law', in M. Ambrus et al. (eds.), *The Role of 'Experts' in International and European Decision-Making Processes: Advisors, Decision Makers or Irrelevant Actors?* (2014), 44, at 47.

[29]L. Gruszczynski, 'Science and the Settlement of Trade Disputes in the World Trade Organization', in B. Mercurio and N. Kuei-Jung (eds.), *Science and Technology in International Economic Law: Balancing Competing Interests* (2014), 11 at 12.

policies against foreign investment.[30] Scientific authority can be a strategic asset for judges as well. Adjudicators may benefit from relying on scientific knowledge claims in deciding economically or politically sensitive disputes, as 'scientific' reasons appear as objective and neutral bases for announcing their findings.

Not only science, but also the law is capable of lending epistemic authority to knowledge claims in the courtroom.[31] The epistemic complexities of scientific disputes can be traced back, on the one hand, to the fact that the authority of science is not hierarchically subordinate to but juxtaposed with legal authority, and presents itself in a litigious context as an independent, equally persuasive extra-legal source of knowledge. Analogously to the Roman law maxim *par in parem non habet imperium*, legal authority cannot invalidate scientific knowledge claims. The presence of science in litigation therefore challenges the discretionary monopoly of judges over the dispute resolution process. Whereas adjudicators have full discretion to interpret legal rules, and are endowed with the requisite epistemic competence, science is more 'wicked', as it is not at their disposal. The interpretative room for manoeuvre is significantly reduced for judges when scientific authority enters the adjudicative process. In order to do justice to the cognitive authority of scientific knowledge permeating the case, judges will need experts to elucidate scientific facts to them;[32] and will have to craft a reasoning that does not refute the logic of science. Furthermore, to assume responsibility for the substance of the judgment rendered, they will also need to understand the scientific aspects of the dispute, an aspect addressed in more detailed later in this analysis.

Another epistemic hardship of science-intensive adjudication stems from the fact that judges normally come untrained in natural sciences. Any epistemic conflict between truths claimed by science and those of law in the litigious context, which abounds in scientific adjudication, has to be resolved by legally trained adjudicators. For instance, a specific causal link, which may be established by experts for purposes of scientific research, may fall short of being recognized as a legally relevant causal nexus.[33] In an extreme scenario, scientifically unfounded or biased (and, thus, scientifically illegitimate) positions can be found legally persuasive in the courtroom, when submitted by experts who can present their findings in an intelligible way to judges during cross-examination.

3. Epistemic legitimacy and the judicial argumentative space

Even though scientific disputes, by their very nature, feature science-based arguments, judges do not necessarily base their reasoning on scientific rationality when deciding on the legal issue at hand. International courts are not always concerned with the merits of scientific arguments, and thus with scientific rationality, when deciding whether a certain environmental harm is caused by a conduct, or a sovereign's risk assessment decision is justifiable in light of genuine environmental and health hazards. As will be shown in more detail in Section 4, international courts sometimes reason using legal or everyday rationality in deciding science-based legal questions. In other words, scientific, legal, and everyday rationality may all be present in the adjudicatory reasoning.

The interaction, and occasional conflict, between the different types of rationality in a litigious process point to some fundamental epistemic questions. Can a legal position be deemed legitimate for the purposes of resolving the legal dispute if it is scientifically unfounded (and, thus, scientifically illegitimate)? Can (and should) scientifically untrained adjudicators appeal to the epistemic authority of science in their reasoning? Should non-scientific rationalities always give

[30]*Methanex Corporation v. The United States of America,* UNCITRAL, Final Award of 3 August 2005, Part IV – Chapter E, para. 19.

[31]D. L. Faigman, 'Where Law and Science (and Religion) Meet', (2014) 93 *Texas Law Review* 1659, at 1659.

[32]C. E. Foster, 'New Clothes for the Emperor? Consultation of Experts by the International Court of Justice', (2014) 5 *Journal of International Dispute Settlement* 139, at 152.

[33]In the context of climate change litigation see *Lliuya v. RWE AG*, Case No. 2. O 285/25, Judgment of 15 December 2016, Essen District Court.

way to scientific authority in forming the epistemic basis of a judicial decision? If not, how should courts decide to which type of rationality they should have recourse when crafting their judgment?

This article suggests that the most useful conceptual compass to answer the above epistemic queries lies in the notion of epistemic legitimacy. Legitimacy means the right to rule[34] and, in the specific context of litigation, the capacity to make authoritative findings in the opinion of the relevant audiences. Philosophers of law suggest that the extent to which legal rules may claim legitimate authority is not independent from reasons rooted in other types of rules and rationalities.[35] The concept of epistemic legitimacy flags similar concerns in the narrower context of judicial reasoning by positing that a judgment which does not treat scientific knowledge appropriately will prove epistemically illegitimate and, therefore, unconvincing.[36] This specific understanding of legitimacy stipulates that only those judgments that duly respect the logic of scientific knowledge in the ways in which scientific input is reflected on in the reasoning can claim legitimacy. This also means that relying on scientific expertise in a judgment only enhances the legitimacy of that decision if the scientific opinion is properly accounted for.[37] Put at its most straightforward, not only the substance of a decision, but also the style of reasoning influences the extent to which a judgment may claim legitimacy. In the context of scientific adjudication, the legitimacy of reasoning is, therefore, inextricably tied to whether and how science is taken into account by adjudicators in their decisions.

3.1 Epistemic risks threatening the legitimacy of the judicial reasoning

Courts may choose one of two main strategies to handle the scientific knowledge involved in the legal dispute. They may either use scientific rationality as the epistemic underpinning of their argumentation, and thereby increase the science-intensity of their reasoning; or they may avoid direct reliance on science, and reason using non-scientific rationality instead. Judges will face specific risks endangering the epistemic legitimacy of their reasoning on both argumentative pathways. These risks are depicted in Figure 1 in a two-dimensional matrix. This figure shows that distinct types of risks threaten to undermine the epistemic legitimacy of the judicial reasoning, and these are dependent upon two main factors: the degree of judicial reliance on scientific expert advice (see vertical axis) and the science-intensity of the judicial reasoning (see horizontal axis).

The matrix reveals that the judicial reasoning becomes vulnerable to legitimacy challenges towards the extremes of both axes, marked with grey boxes. Zooming in first on the horizontal axis, the graphic shows that international courts and tribunals may legitimately reflect on and incorporate scientific knowledge in their reasoning up to the point when they would become entangled in speculations about the scientifically 'correct' answer to the technical debate that lies in the background to the legal controversy. Put differently, increasing the science-intensity of the reasoning becomes harmful for the epistemic legitimacy of the decision when it induces the bench to cross epistemic lines, by venturing into resolving scientific questions regarding which they lack epistemic competence. Nevertheless, it is sometimes suggested that international judicial bodies ought to decide the underlying scientific controversy itself[38] and thereby act as 'science courts'[39] in

[34]A. Buchanan, 'The Legitimacy of International Law', in S. Besson and J. Tasioulas (eds.), *The Philosophy of International Law*, (2010), 79, at 79.

[35]For such deflationary views on legal authority and normativity see N. Gur, 'Legal Facts and Reasons for Action: Between Deflationary and Robust Conceptions of Law's Reason-Giving Capacity', in N. Bersier, C. Bezemek and F. Schauer (eds.), *The Normative Force of The Factual: Legal Philosophy Between Is and Ought* (2019), 151.

[36]See Thomas, *supra* note 8, at 288.

[37]J. Lawrence, 'The Structural Logic of Expert Participation in WTO Decision-Making Process', in Ambrus et al., *supra* note 28, at 173.

[38]*U.S. – Continued Suspension of Obligations in the EC – Hormones dispute*, Report of the Panel, WT/DS320/R, 31 March 2008, para. 7.420.

[39]This has been suggested by the respondent in *Glamis Gold, Ltd. v. The United States of America*, UNCITRAL, Award of 8 June 2009, para. 617.

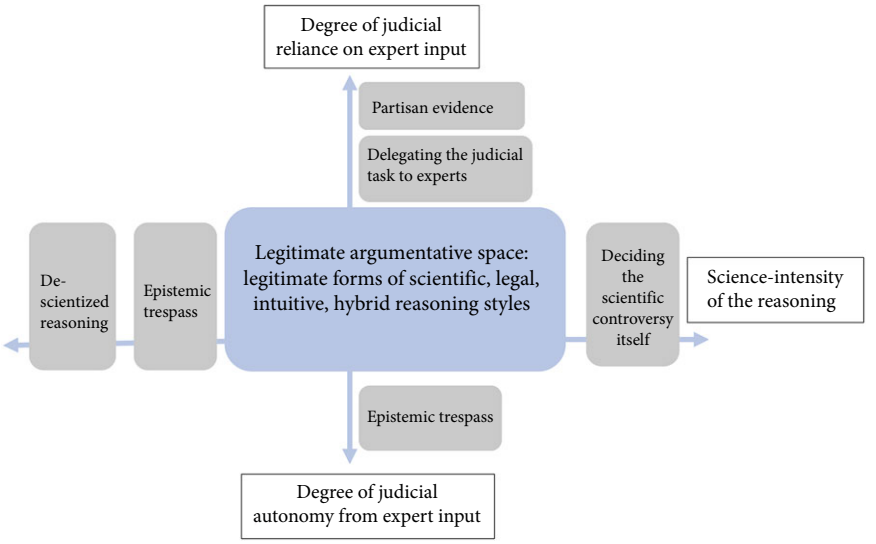

Figure 1. On the limits of the legitimate judicial argumentative space.

cases that rest on contested scientific views. However, such a too-science heavy configuration of the judicial purview clearly falls outside the scope of the legitimate adjudicatory function. Judges ought not to decide on the scientific validity of an expert position or seek to find 'the' scientifically correct answer in disagreements between experts.[40] Such a task is reserved for the scientific community and therefore, any judicial speculation in this regard would be epistemically illegitimate, as marked at the right end of the horizontal axis. Except for such extreme scenarios, however, courts may legitimately attempt at engaging with scientific rationality, if they benefit from the necessary epistemic support, as will be discussed later in more detail.

Moving now along the horizontal axis to the left, it becomes apparent that the epistemic legitimacy of a decision can be threatened equally by engaging with too little science. Epistemically illegitimate decisions may not only arise when adjudicators want to reason *with* science excessively (in the sense outlined above), but also when they wish to justify their findings *without* reference to scientific authority regarding manifestly science-intensive issues. Epistemic trespass,[41] flagged on the left extreme of the horizontal axis, stands for scenarios when judges intentionally seek to avoid confrontation with scientific knowledge in their reasoning. D'Aspremont and Mbengue already highlighted such a scenario and termed them epistemically arbitrary decisions. Reasoners commit such a fallacy when they appraise the validity of a knowledge claim according to the standards of another epistemic realm.[42] In the context of science-heavy adjudication, this typically occurs when scientific knowledge claims are judged solely according to legal or intuitive rationality. As a caveat, it is to be noted here that not every form of legalistic or intuitive reasoning leads to epistemically arbitrary decisions. Section 4 will highlight scenarios when the application of legal or intuitive rationality in the adjudicatory decision does not seek to run counter to or replace scientific knowledge, and therefore does not entail epistemically arbitrary decisions.

[40]*Pulp Mills on the River Uruguay (Argentina v. Uruguay)*, Judgment of 20 April 2010, [2010] ICJ Rep. 14, para. 4 (Judges Al-Khasawneh and Simma, Joint Dissenting Opinion): 'the task of a court of justice is not to give a scientific assessment of what has happened'.

[41]For more on the epistemic nature and consequences of such a fallacy see N. Ballantyne, 'Epistemic Trespassing', (2019) 128 MIND 367.

[42]See D'Aspremont and Mbengue, *supra* note 10, at 268.

The above notwithstanding, downplaying the role of science in the judicial reasoning in scientific disputes is often problematic from an epistemic legitimacy point of view. A major risk is epistemic trespassing, which is primarily located around the lower extreme of the horizontal axis, and which occurs, when courts and tribunals essentially replace scientific rationality with non-scientific epistemic standards. A most salient example is when judicial reasoning unduly subordinates scientific logic that is otherwise available for adjudicators to other types of rationality, for instance by judging essentially scientific concepts, such as 'significant risks' without considering pertinent scientific evidence on the matter. Certain fact-finding techniques are especially conducive to such a treatment of scientific authority; for instance, when a judicial body chooses not to gather expert evidence in a science-intensive case, disregards the expert opinions received or provides only a superficial assessment of the parties' technical submissions. An extreme form of such outright judicial avoidance strategies towards the scientific dimensions of disputes would essentially 'descientize' scientifically-loaded legal controversies, as marked at the left extreme of the horizontal axis. This not only leads to epistemically arbitrary decisions, but it may also contradict scientific realities. Specific illustrations of such judicial argumentative pathways will be addressed in Section 4.

The vertical axis represents another, though related, set of legitimacy challenges for scientific adjudication. These concern the appropriate role of scientific experts in the dispute resolution process. Simply put, over-extensive reliance on experts may be just as problematic as claiming too much independence from them. The upper end of the vertical axis represents the epistemic risks stemming from the delegation,[43] or even abdication,[44] of the judicial task to non-accountable experts, whereby judges become too dependent on the scientific advice received, whereas the lower end of the vertical axis represents the judicial attitude, when legally-trained judges claim too much autonomy from experts and would choose among essentially scientific knowledge claims on their own, without hearing or evaluating expert evidence, which would constitute epistemic trespass (see grey box at the lower end of the vertical axis).

Turning now to the legitimacy risks emerging at the upper extreme of the vertical axis, one finds scenarios when judges become epistemically overdependent on what they receive from experts. In such cases, adjudicators automatically rubberstamp scientific opinions without exerting any cognitive control over the expertise, which will be then allowed to act as the final arbiter of the contested legal issues. Even though in such cases the judicial decision incorporates and is essentially built on scientific rationality, it does so in an illegitimate way. This is because, in such cases, legal adjudicators delegate the judicial monopoly to experts, as they do not exert any meaningful cognitive control over the expert opinions that dictate the judicial findings. A related risk applies if courts conduct only superficial evidentiary assessments of the expert opinions. In such cases, judges easily fall prey to partisan evidence, which is tainted with advocacy to such an extent that its evidentiary value is seriously compromised.[45] The factual basis of such judicial findings is likely to be both legally and scientifically illegitimate.

3.2 Pathways to crafting epistemically legitimate reasoning: A need for cognitive control

Once the above legitimacy risks are averted, international courts and tribunals can navigate over a considerably wide epistemically legitimate argumentative space, where their reasoning does not undermine scientific epistemic authority. Judicial reasoners can choose between two main pathways to accommodate and conform to the logic of science in the reasoning, and therefore

[43]C. Payne, 'Mastering the Evidence: Improving Fact Finding by International Courts' (2011) 41 *Environmental Law* 1191, at 1195.

[44]M. M. Mbengue, 'The South China Sea Arbitration: Innovations in Marine Environmental Fact-Finding and Due Diligence Obligations', (2016) 110 *AJIL Unbound*, 285, at 289.

[45]*Pulp Mills on the River Uruguay (Argentina v. Uruguay)*, Judgment of 20 April 2010, [2010] ICJ Rep. 14 para. 27 (Judge Greenwood, Separate Opinion); see Boisson de Chazournes et al., *supra* note 4, at 492.

observe the imperative of epistemic legitimacy. They either reflect and reason using scientific rationality or decrease the science-intensity of their findings and turn to non-scientific forms of epistemic rationality. These two main strategies translate to four distinct reasoning styles, depending upon their underlying rationality, which will be analysed in greater detail in Section 4.

Before delving into the particularities of different argumentative styles, it is important to underline that not every form of non-scientific reasoning mistreats the cognitive authority of science and, thus, is detrimental to the epistemic legitimacy of reasoning. Note, on the vertical axis of Figure 1 above, that the legitimate argumentative space expands to essentially non-scientific rationality, by spanning below the horizontal axis. The key in this respect lies in appraising whether scientific knowledge is available in the given dispute to buttress adjudicatory conclusions. Notably, when scientific knowledge is too ambiguous or so scarce that it is unable to support legally legitimate (persuasive) judicial findings, adjudicators may justifiably turn to non-scientific rationalities.

In other words, making epistemically arbitrary findings can be avoided in two main ways, depending upon whether respective judges aim to appeal to scientific or non-scientific rationality in their reasoning. In the first pathway, when judicial reasoners opt to rely on scientific rationality, the epistemically most robust solution would be to appoint adjudicators who are trained in both the legal and the scientific realm.[46] However, expert judges or arbitrators with scientific or even double qualifications remain a rarity in international practice,[47] and adjudicators wearing double hats may not become the norm in international scientific dispute resolution any time soon.

Importantly, however, even legally-trained adjudicators can respect epistemic lines, as long as they do not venture into deciding on scientific validities and the correctness of expert positions. In other words, international judges can engage with the scientific profile of disputes in epistemically legitimate ways. Philosophers offer two key routes in this respect. Brewer emphasizes the possibility for augmenting the scientific epistemic competence of legally-trained judges, so that they do not make epistemically arbitrary choices,[48] whereas Ballantyne points out the importance of not committing epistemic trespass alone,[49] meaning that judges can guard against epistemically arbitrary trespassing by having recourse to expert assistance. In addition, the present research argues that the legitimacy of the decision also requires that judicial reasoners engage with the evidence received in a meaningful way. Reading the upper part of the vertical axis together with the right wing of the horizontal one on the matrix above shows that, the legitimacy of the judicial decision requires that adjudicators successfully preserve their monopoly over the dispute resolution process. This necessitates exerting cognitive control over the scientific expertise, which can be achieved if judges develop an overall understanding of the scientific points of contention embedded in the rival legal claims of the parties. Only if judges grasp the main points of the scientific controversy that underlie the legal dispute can they assume an active role in the scientific fact-finding process and assess the rival party-adduced expert evidence meaningfully, which appears as a prerequisite to buttressing the epistemic legitimacy of judgments that refer to scientific rationality.

In the other judicial pathway, when courts choose to reason with non-scientific rationality, adjudicators can stop trespassing by confining their decision to a narrower issue that safely falls within their epistemic competence.[50] In such cases, judges remain in the terrain of legalistic analysis or intuitive reasoning. To observe epistemic legitimacy, judges need to ensure that their 'descientized' reasoning does not contradict scientific knowledge and authority pertaining to the case. This again necessitates that judges develop scientific literacy so they can appraise what scientific insights can address the legal question at hand.

[46]S. Brewer, 'Scientific Expert Testimony and Intellectual Due Process', (1998) 107 *Yale Law Journal* 1535, at 1539.
[47]See Section 3.2 for more details in the domestic and international case law.
[48]See Brewer, *supra* note 46, at 1678.
[49]See Ballantyne, *supra* note 41, at 389.
[50]Ibid., at 376.

The above suggests that preserving the epistemic legitimacy of judgments ultimately hinges on the extent to which judges can exert cognitive control over the scientific aspects of disputes. Even so, can legally-trained adjudicators be reasonably expected to expand their epistemic competence to do so? Although doing so would admittedly confer an ambitious and epistemically arduous task on members of international courts and tribunals, we have reasonable grounds, both theoretical and empirical, to suggest a positive answer.

From an epistemic point of view, it is plausible that non-expert judges can become sufficiently familiar with different fields of science to reach decisions in an epistemically non-arbitrary way.[51] Such a goal can be achieved in practice through several avenues. Firstly, judges may acquire the necessary technical knowledge through training, or can accumulate sufficient judicial experience in fact-intensive litigation, through which they become familiar with the technical knowledge pertaining to the cases. It should be stressed that all this in no way suggests that judges need to become super-experts in highly technical fields. The proposition here is more modest than that. Formulating a basic understanding of the sciences in the case at hand would suffice for maintaining cognitive control over the scientific dimensions. Emphatically, judges ought only to become cognisant of what science can and cannot deliver for the judicial process. More concretely, they need only to familiarize themselves with the basic tenets of the scientific method and the fundamental differences between the methodology and language of legal and scientific inquiry.[52]

Turning to the first possibility, the epistemic competence of courts may be augmented through training organized for judges and/or staff members. Judicial good practices at the domestic level suggest the workability of such capacity-building techniques. National courts hearing environmental disputes have applied such training, and participating judges deem such programmes effective.[53] There is also grounds for optimism with respect to the willingness and ability of international judges to grapple with highly technical questions. In the *Whaling in the Antarctic* case, the scientist acting as Australia's expert formed a very optimistic view on how quickly members of Court familiarized themselves with scientific methodologies and actively engaged with the position presented by the experts.[54]

Certain fact-finding techniques can also strengthen the epistemic competence of judicial bodies. The bench may incorporate scientific expertise via appointing expert judges or arbitrators, whenever it is allowed by the institutional set-up of the court.[55] They may also appoint *ex curia* experts,[56] who can assist the court with understanding the experts' positions, thereby exercising a closer interaction with party-submitted evidence.[57] So far, however, international forums have been notably reluctant to use their existing powers of relying on court-appointed experts,[58] and the

[51]See Brewer, *supra* note 46, at 1678.

[52]H. Kritzer, 'The Arts of Persuasion in Science and Law: Conflicting Norms in The Courtroom', (2009) 72 *Law and Contemporary Problems* 41; see Sulyok, *supra* note 2, Ch. 2.

[53]K. Sulyok et al., 'Summary Report of the European Forum of Judges for the Environment, Answers to the Questionnaire Concerning the Role of Science in Environmental Adjudication', 2019, at 26, available at www.eufje.org/images/docConf/hel2019/Summary_report_Questionnaire_EUFJE2019.pdf.

[54]M. Mangel, 'Whales, Science, and Scientific Whaling in the International Court of Justice', (2016) 113 *Proceedings of the National Academy of Sciences* 14523, at 14526.

[55]As a matter of law of procedure, several forums have the power to appoint expert assessors or expert judges, such as the PCA, ICJ, ITLOS, and the WTO dispute settlement bodies. However, except for the PCA, they have not availed themselves of such an opportunity in environmental disputes.

[56]E.g., *Perenco Ecuador ltd. v. Ecuador and Emprese Estatal Petróleos del Ecuador (Petroecuador)*, ISCID Case No. ARB/08/6, Interim Decision on the Environmental Counterclaim of 11 August 2015; D. Peat, 'The Use of Court-Appointed Experts by The International Court of Justice', (2014) 84 *British Yearbook of International Law* 271.

[57]N. Blackaby and A. Wilbraham, 'Practical Issues Relating to the Use of Expert Evidence in Investment Treaty Arbitration', (2016) 31 *ICSID Review* 655, at 655; B. Simma, 'The International Court of Justice and Scientific Expertise' (2012), 106 *Proceedings of the Annual Meeting (ASIL)* 230, at 232.

[58]See Sulyok, *supra* note 2, at 281–2.

use of expert arbitrators also remains a rarity in international practice.[59] The *Perenco* arbitration provides an early example for gathering independent expert advice, which was instrumental to fill the void left by the excessively biased, partisan evidence.[60] The tribunal famously noted that the parties' experts 'crossed the boundary between professional objective analysis and party representation',[61] and hence were of little use for the panel, and it therefore commissioned its own expert to re-sample the contaminated sites mentioned in the party-submitted expert reports.[62] Also, more recently, in the reparations judgment in *Armed Activities*, the ICJ appointed an independent expert to evaluate the ecological damage caused by Ugandan forces, and found that the expert evidence provided a 'more persuasive assessment and valuation of the damage' than what had been submitted by the parties.[63] Interestingly, however, the independent expert advice ultimately had a markedly different impact on the reasoning in the material cases, which will be addressed below.[64]

Furthermore, tribunals in *Perenco* and *Burlington Resources* also made site visits to inspect first-hand the extent of oil contamination and soil degradation, where the arbitrators could even ask questions on the record to the parties and their experts.[65] This fact-finding tool arguably also significantly contributed to the close incorporation of science in the adjudicatory findings.

What is argued here is that even judges without an in-depth professional background in natural sciences are able to formulate a basic understanding of the scientific profile of the legal controversy, which would allow them to maintain cognitive control over the scientific aspects of the disputes and thereby satisfy the prerequisite of making epistemically legitimate decisions. Developing scientific literacy is necessary for judges to meet their 'epistemic responsibility'[66] in scientific adjudication. Once adjudicators are willing to accommodate scientific knowledge and rationality in their analysis, they can assume a more proactive role in scientific fact-finding and may reflect meaningfully on the technical arguments in their reasoning. Courts can become 'sophisticated consumers'[67] of scientific findings.

4. The argumentative toolkit of international courts: Scientific, legal, hybrid, and intuitive reasoning in scientific disputes

Let us now turn to discussing how the requirements of legitimate reasoning, as identified above, are met in the argumentative practice of international courts. This section therefore shows how different types of rationality operate in the judicial reasoning of international courts in environmental disputes. In deciding legal controversies imbued with scientific knowledge and proof, judges may either refer to scientific rationality (see Section 4.1) or they may rely on non-scientific rationality to buttress their conclusions, such as legalistic or everyday logic (see Sections 4.2 – 4.4). If certain conditions are met, reasoning using non-scientific rationality does not unduly

[59]Thus far the Permanent Court of Arbitration is the only permanent forum using such a technique. It appointed an expert arbitrator only once, in the *Indus Waters Kishenganga arbitration, Pakistan v. India*, Partial Award of 18 February 2013, Final Award of 20 December 2013.

[60]*Perenco Ecuador ltd. v. Ecuador and Emprese Estatal Petróleos del Ecuador (Petroecuador)*, ISCID Case No. ARB/08/6, Interim Decision on the Environmental Counterclaim of 11 August 2015.

[61]Ibid., para. 581.

[62]Ibid., paras. 590–592. For more details on the fact-finding techniques of the tribunal see J. Rudall, 'The Tribunal with a Toolbox: On Perenco v Ecuador, Black Gold and Shades of Green', (2020) 11 *Journal of International Dispute Settlement* 485.

[63]*Case Concerning Armed Activities on the Territory of the Congo (DRC v. Uganda)*, Judgment of 9 February 2022, [2022] ICJ Rep. 13, paras. 269, 277.

[64]See Sections 4.1.1 and 4.3.5, *infra*.

[65]*Burlington Resources Inc. v. Republic of Ecuador*, ICSID Case No. ARB/08/5, Decision on Counterclaims of 7 February 2017, para. 20.

[66]E. Fisher, 'Science, Environmental Laws, and Legal Cultures: Fostering Collective Epistemic Responsibility', in E. Lees and J. E. Vinuales (eds.), *The Oxford Handbook of Comparative Environmental Law* (2019), 749, at 763.

[67]See Faigman, *supra* note 31, at 1679.

replace or refute scientific logic, and thus these methods of legalistic or intuitive reasoning form part of the epistemically legitimate argumentative toolkit. Nevertheless, in certain scenarios, decreasing the profile of scientific rationality in the judicial reasoning does lead to epistemic illegitimacy. These nuanced circumstances will be detailed with respect to each argumentative style.

Another important caveat is that science-based judicial reasoning cannot be deemed universally superior, or more legitimate (from an epistemic point of view) than other reasoning styles. Non-expert judges' reasoning using science may also be susceptible to legitimacy challenges, and may not even be possible in every legal dispute. Furthermore, different epistemic rationalities may inevitably coexist, or even impact one another to some extent, in a given reasoning. Nevertheless, it is possible to identify the type of rationality that plays a dominant role in shaping the inquiry. Furthermore, there is no single 'ideal' argumentative style, nor is there an abstract hierarchy for these modes of reasoning.[68] Rather, different modes of reasoning may have a better fit with differing factual scenarios, depending upon several parameters, which will be analysed in Section 5.

4.1 Scientific rationality in judicial reasoning

The cognitive authority of science sometimes prompts adjudicators to incorporate scientific knowledge directly into their appraisal. In such cases, adjudicatory decisions directly draw on the cognitive power of science to justify a particular judicial choice between rival science-based positions. In these decisions, the seemingly 'objective' and 'neutral' scientific authority buttresses the persuasiveness of the adjudicatory assessment. In the scientific reasoning style, the methods of a particular scientific field lay the foundation for the judicial conclusions and provide the ultimate benchmark against which the parties' claims are measured. As a result, these argumentative techniques are epistemically deferential to scientific opinion, as the acceptability of expert opinions are ultimately judged by the standards provided by scientists. A corollary of such an 'outsourcing'[69] technique is a close reliance on experts, who speak to the court on behalf of the scientific community regarding the techno-scientific merit of the parties' submissions.

The scientific reasoning method therefore often instructs adjudicators to follow blindly the opinion of a group of scientists on the acceptability of evidence, which raises the risk of judges becoming too dependent on expert assistance. However, when adjudicators strengthen their epistemic capacity through appropriate fact-finding tools and are ready to assess scientific input thoroughly and to consider it carefully in their assessment, scientific rationality will enjoy a high profile in the reasoning without generating legitimacy concerns.

4.1.1 Concrete examples from international case law

The WTO jurisprudence provides perhaps the most salient example of a judicial reasoning, which affords an express role for scientific rationality. Under the Agreement on the Application of Sanitary and Phytosanitary Measures (SPS Agreement), WTO dispute settlement bodies need to decide whether a WTO Member's scientific risk assessment is in conformity with the Agreement. More specifically, WTO panels are obliged to determine whether the scientific risk assessment underlying the trade measure under review is supported by 'respectable scientific evidence'.[70] In view of the Appellate Body, to qualify as such, an acceptable scientific position must have 'the necessary scientific and methodological rigor to be considered reputable science', and must be

[68]For the same proposition in the context of using different types of rationality to justify evidentiary findings see D'Aspremont and Mbengue, *supra* note 10, at 271.

[69]Ibid., at 258–63.

[70]*U.S. – Continued Suspension of Obligations in the EC – Hormones dispute*, Report of the Appellate Body, WT/DS320/AB/R, 16 October 2018, para. 590.

considered 'legitimate science according to the standards of the relevant scientific community'.[71] As is apparent from this language, the adjudicatory reasoning in such cases directly refers to the authority of the *scientific* community in setting the *legal* requirements for accepting a piece of expert evidence in the dispute resolution context.

Another argumentative appeal to scientific rationality, where judicial authority automatically adopts an expert position as its own without meaningful scrutiny, occurs when international tribunals prescribe expert-led consultation for litigants to reach a mutually agreeable solution to their disagreement. This occurred, for instance, in the *Straits of Johor* dispute, which was launched by Malaysia against Singapore's land reclamation scheme for being likely to cause harm to the marine environment. The core of the parties' disagreement revolved around the interpretation of scientific data on the possible adverse effects of the infilling works. ITLOS, which issued the interim measures in the proceedings, ordered the co-operation of the parties, specifically by establishing a jointly selected group of independent experts to commission a study and to propose measures to deal with any adverse effects.[72] The expert panel adopted its final report unanimously, which was considered a significant factor in the parties' adopting it as a solid basis for their settlement.[73] The Settlement Agreement later simply reiterated the recommendations of the group of experts and was annexed to the Award on Agreed Terms concluding the dispute on the merits.[74]

A further technique is illustrated by the *Burlington Resources* decision on counterclaims, part of which concerned the valuation of ecological damage caused by oil pollution in the Amazon. This provides a case in point of a decision in which adjudicators did not delegate the task of engaging with scientific knowledge to experts, but retained their epistemic control by reconstructing the scientific bases of their own findings on the basis of rival data offered by the parties. It is noteworthy, first of all, that the *Burlington Resources* panel was ready to examine the expert reports closely to identify points of agreement and disagreement between them and even dismissed those pieces of expert evidence that had not been generated 'in line with standard practice'.[75] The tribunal also took on the task of reviewing 74 soil contamination sites individually in a roughly 140-page long assessment, which was necessary to evaluate the technical depths of the parties' contrasting views and highly detailed submissions.[76] This part was followed by a review of the clay content and sampling results of 46 groundwater remediation sites. The fact that the parties took more than 3,500 samples regarding the soil contamination aspect of their dispute alone[77] fairly illustrates the extreme science-intensity of the factual record facing the adjudicators. One must all the more appreciate the panel's scientifically-informed legal assessment, as the decision's level of detail duly resembled the fine-grained and technical nature of the parties' points of contention. Indeed, the *Burlington Resources* decision on counterclaims stands out in international jurisprudence due to its language, which thoroughly incorporates scientific data and draws legal conclusions directly from a detailed assessment of expert positions.

4.1.2 Impact on legitimacy

Reasoning on the basis of scientific authority, in principle, increases the scientific accuracy of decisions, which, in turn, is beneficial to the epistemic legitimacy of judgments. This

[71] Ibid., para. 591.

[72] *Land Reclamation by Singapore in and around the Straits of Johor (Malaysia v. Singapore)*, Provisional Measures, Order of 8 October 2003, [2003] ITLOS Rep. 10, Operative part section (a) paragraph (i).

[73] T. Koh and J. Lin, 'The Land Reclamation Case: Thoughts and Reflections', (2006) 10 SYBIL 1, 5.

[74] *Land Reclamation by Singapore in and Around the Straits of Johor (Malaysia v. Singapore)*, PCA Case No. 2004-05, Award on Agreed Terms of 1 September 2005.

[75] *Burlington Resources Inc. v. Republic of Ecuador*, ICSID Case No. ARB/08/5, Decision on Counterclaims of 7 February 2017, para. 856.

[76] Ibid., at 199–337.

[77] Ibid., at 430, 432.

argumentative practice can also respect epistemic non-arbitrariness. Some of its forms enable adjudicators to make a clear delineation of the questions on which they adopt a 'radically epistemically deferential'[78] approach towards expert assessments and, thus, adjudicators would not cross epistemic lines. In the case of other scientific reasoning techniques, legal reasoners do not delegate the task of scientific engagement entirely to experts. In such scenarios, the epistemic precondition for crafting epistemically legitimate argumentation is that judicial reasoners acquire the necessary epistemic competence to assess the expert input thoroughly. Practical solutions to meet this requirement have been addressed above in Section 3.2.

It is also important to highlight that affording deference to scientists may not always yield a final legal answer to the judicial dilemma. As pointed out by Judge Donoghue extra-judicially, '[d]eferring to science ... cannot solve the relevant legal question, although it can produce a wealth of impressive sounding information'.[79] As such, it ultimately remains the task of adjudicators to become ascertained of the facts of the case, even if they choose to rely on expert evaluations regarding factual matters. In other words, even accepting the superior epistemic authority of scientists to appraise the merits of expert evidence, deference to scientific standards is usually not the end of a judicial inquiry and it cannot absolve adjudicators from their epistemic duty to engage with the substance of expert evidence. This again points to the importance of judges maintaining cognitive control over the scientific aspects of disputes, as outlined above.

The above notwithstanding, relevant examples from the case law have shown that not every legitimate science-based reasoning requires scientific competence from the judicial panel. When international courts mandate expert-led consultation for litigants, they in essence reason on the basis of scientific epistemic authority, because adjudicators simply reiterate the solutions advised by scientists, and unconditionally endorse the experts' position in mandating the final legal scheme. This argumentative practice is epistemically convenient for those legally trained, as it does not compel them to become entangled in the evaluation of scientific evidence, while the dangers of expert bias and partisan evidence are also precluded due to the consensual appointment of the experts. Finally, as long as adjudicators rely on scientific rationality after a thorough examination of expert evidence with necessary epistemic capacities and support, and do not venture into scientific speculations of their own, the epistemic authority of science is respected in the adjudicatory decision.

It should also be noted, however, that increasing the scientific profile of judicial reasoning does not necessarily lead to greater legitimacy. There may be instances when legally-trained reasoners could be tempted to support their conclusions with reference to scientific views and literature in a way that gives a distorted reading to the evidence and, hence, could be contrasted by the parties or the public with expert positions (by pointing out, *inter alia*, that the respective views do not hold true in light of latest scientific results). In such a hypothetical case, the scientific language of the judgment would not mitigate the epistemic shortcomings of the reasoning.

4.2 Intuitive reasoning

Direct engagement with scientific rationality may not be possible in every case, given the time and monetary constraints of legal proceedings. This gives rise to a need for finding epistemic substitutes for scientific authority. Adjudicators in such cases sometimes turn to everyday knowledge and reason using intuitive rationality. Everyday experience may inform the selection of relevant information forming the premises of the judicial decision. With such a reasoning style, courts can bypass the detailed inferential processes necessary to evaluate the merits of scientific arguments.[80]

[78]See D'Aspremont and Mbengue, *supra* note 10, at 267.
[79]R. Feldman, *The Role of Science in Law* (2009), 42.
[80]See Dwyer, *supra* note 6, at 68.

4.2.1 Concrete examples from international case law

A typical (yet so far unflagged) intuitive type of reasoning lies in semantic analysis, when judges engage in a purely grammatical interpretation of phrases that surround a scientific concept. An apt illustration for such an argumentation can be drawn from WTO jurisprudence. The panels assess whether a certain SPS measure 'conforms to' international standards or is 'based on' a risk assessment, as prescribed by Article 3 of the SPS Agreement, without interrogating the scientific bases of that SPS measure. Instead, WTO panels, in such cases, draw essentially textual-logical inferences from the grammatical meaning of these terms. For instance, they have found that a measure that contradicted an international standard could not be deemed as 'based on' that standard.[81] In another case, adjudicators required a 'very close relationship between two things in order to be able to say that one is "the basis for" the other'.[82] It is to be noted, however, that such an inquiry does not lead to the marginalization of scientific knowledge in the adjudicatory assessment. The WTO panels only apply these techniques to supplement their analysis, as hearing expert evidence is mandatory in SPS cases.[83]

Using second-order indicators in the evidentiary practice of various international courts and tribunals[84] is also rooted in everyday rationality. It allows judges to reason their way out of a direct interaction with first-order scientific evidence by drawing intuitive inferential shortcuts. In this intuitive reasoning technique, the reliability of a given piece of expert evidence is evaluated only indirectly, through higher-order justifications.[85] Instead of interrogating the evidentiary weight of the evidence directly, with reference to scientific rationality, reasoners zero in on the experts' credentials and their perceived independence or impartiality, or the peer-reviewed or uncontested nature of scientific evidence.

Another stark example of basing judicial findings on common sense justification can be drawn from the causal inquiry of the European Court of Human Rights (ECtHR) in toxic exposure cases assessed under the right to private and family life. The ECtHR is known for substituting intuitive, non-scientific proxies for a thorough science-based assessment when it decides on the existence of legally appreciable causal links between toxic emissions and adverse health effects[86], such as the proximity of the applicant's home to the source of toxic emission. Several decisions in the Strasbourg case law suggest that these are deemed by the court to be decisive factors in assessing the toxic potential of chemicals and their causal role in engendering health injuries.[87] For instance, in the *Ivan Atanasov* v. *Bulgaria* case, the ECtHR attached particular relevance to the distance between the polluter's location and the applicant's home, which was used as a proxy for assessing whether the emissions had a 'direct effect' on the applicant's private and family life, which is a condition for triggering the applicability of Article 8. As a reason for refusing to apply Article 8, the ECtHR referred to the fact that the applicant's home was 'a considerable distance' from the tailings pond of a former copper mine, the source of the pollution,[88] although it has long been confirmed by scientists that such chemicals can travel long distances without losing their toxicity.

[81] *United States — Measures Affecting the Importation of Animals, Meat and Other Animal Products from Argentina*, Report of the Panel, WT/DS447/R, 24 July 2015, para. 7.237.

[82] *EC – Sardines*, Report of the Appellate Body, WT/DS231/AB/R, 26 September 2002, para. 245.

[83] SPS Agreement, Art. 11(2).

[84] The use of second-order indicators has been acknowledged by members of the bench in the evidentiary assessment of the ICJ and ITLOS: see J. E. Donoghue, 'Expert Scientific Evidence in a Broader Context', (2018) 9 *Journal of International Dispute Settlement* 379, at 385; Anderson, *supra* note 14, at 518.

[85] O. Perez, 'Judicial Strategies for Reviewing Conflicting Expert Evidence: Biases, Heuristics, and Higher-Order Evidence', (2016) 64 *American Journal of Comparative Law* 75.

[86] K. Sulyok, 'Managing Uncertain Causation: Lessons for the Strasbourg Court from U.S. Toxic Tort Litigation?', (2017) 18 *Vermont Journal of Environmental Law* 521.

[87] E.g. *López Ostra v. Spain*, Judgment of 9 December 1994, [1994] ECHR; *Ivan Atanasov v. Bulgaria*, Judgment of 2 December 2010, [2010] ECHR, para. 76.

[88] Ibid., *Ivan Atanasov v. Bulgaria*, para. 76.

Notably, in the material case, the risk assessment report of the national authority also found a risk of contamination from the pond's sludge within a radius of ten kilometres from it.[89]

Another epistemically arbitrary, intuitive reasoning is displayed in *Kyrtatos* v. *Greece*. The proceedings concerned a claim of a homeowner on a Greek island, filed for an alleged violation of their right to private and family life for destroying a protected swamp area adjacent to their home. The ECtHR opined that damage to the protected species and the habitat did not affect their rights directly, making Article 8 inapplicable. However, it also noted that '[i]t might have been otherwise if, for instance, the environmental deterioration complained of had consisted of the destruction of a forest area in the vicinity of the applicants' house, a situation which could have affected the applicants' own well-being more directly'.[90] Such a distinction between the impacts of a wetland and a forest on human well-being, although it may at first glance be intuitively convincing for laypeople, is clearly refuted by ecological research, which does not know any appreciable difference between the ecosystem services[91] provided by these habitats.

In short, a problematic aspect of this type of intuitive reasoning lies in running against established scientific knowledge. These judgments highlight instances when scientific insights undermine the factual accuracy of the ECtHR's intuitive reasoning, and thereby diminish the legitimate and persuasive nature of the judicial findings.

4.2.2 Impact on legitimacy

Relying on common-sense rationality undoubtedly comes with certain benefits. It preserves the judicial monopoly over the dispute resolution process, as reasoning this way fits well with the epistemic capacities of legally-trained reasoners. This reasoning is also usually intuitively persuasive for both judges and litigants as a means of locating legitimate knowledge claims. Nevertheless, this argumentative style forms a heterogenous category, comprising epistemically illegitimate and legitimate methods. When applied *in lieu* or in contravention of scientific knowledge available to the proceedings, it leads to epistemically arbitrary decisions. In such scenarios, intuitive reasoning is objectionable from a legitimacy point of view.

Distinct forms of intuitive reasoning come with specific legitimacy risks. Employing second-order indicators may lead to, or at best tolerate, cognitive fallacies. The reputation of scientists in fact says little, if anything, about the scientific merit of their opinions that may be dismissed based on second-order justifications. Even highly eminent scientists may fall prey to good faith cognitive, or even express economic bias, which would go unnoticed under such a formalistic assessment. Features such as the impartiality or independence of experts are vaguely defined and inherently subjective. An empirical survey shows a lack of consensus among international judges on what these notions actually mean.[92] Another peril of reasoning using second-order evidence is that it often leads to obscure justifications. This is problematic because international judges have already been suspected of not revealing their real motivations behind particular decisions,[93] and reasoning using second-order justifications makes it dangerously easy for judges to hide their subjective appraisals from public scrutiny.

However, an intuitive argumentative style may provide a legitimate way of reasoning under certain circumstances. For instance, semantic reasoning confines the judicial inquiry to a grammatical interpretation of non-technical terms, which are expressly enshrined in the legal text applicable to the legal controversy. As a result, such an inquiry guards against epistemic trespass,

[89]Ibid., paras. 31–34.

[90]*Kyrtatos v. Greece*, Judgment of 22 May 2003, [2003] ECHR, para. 53.

[91]J. Maes et al., 'Mapping and Assessment of Ecosystems and Their Services: An EU Ecosystem Assessment', (2020) *JRC Science for Policy Report*.

[92]See Boisson de Chazournes et al., *supra* note 4, at 504.

[93]See Griss, *supra* note 7, at 249; B. A. Spellman and F. Schauer, 'Legal Reasoning', in K. Holyoak and R. Morrison (eds.), *The Oxford Handbook of Thinking and Reasoning* (2012), 719, at 722.

since the reasoners do not invoke substantive scientific standards when deciding which of the parties' scientific narratives shall be accepted in the dispute. The legitimacy of semantic analysis is further buttressed by the fact that it is normally applied to complement the interpretation of expert evidence; as such, it does not serve to circumvent or eliminate scientific rationality from the ambit of judicial inquiry. In sum, if applied as a complementary or auxiliary means of justification; in other words, when scientific rationality is not available or sufficient to scaffold the judicial findings in a given case, an intuitive reasoning style preserves the epistemic legitimacy of the inquiry.

4.3 Legal reasoning

When judges circumvent scientific epistemic standards in their inquiry, they often turn to legalistic reasoning. It is perhaps unsurprising that the majority of argumentative practices employed in science-heavy cases fall into this category. There is a wide array of tools that justify adjudicatory choices between competing scientific claims with reference to standards that are deemed authoritative by virtue of legal logic alone. These reasoning techniques are therefore not available for every reasoner; what is more, the 'esoteric legal reality'[94] created by law's own language is often unintelligible and may not even be persuasive to non-lawyers.

4.3.1 Reference to scientific standards issued by competent organizations

Courts sometimes accept a piece of scientific evidence as reflecting 'valid' science, which would be acceptable for the judicial process, by checking whether it matches the scientific guidelines issued by competent international bodies. Relevant examples can be drawn from WTO case-practice and investment arbitration case law.[95] In certain legal contexts, deeming such technical guidelines as indicia of valid scientific positions is mandated by express provisions; in others, this reasoning method is voluntary and stems from the conscious choice of the judicial reasoner. The SPS Agreement, for instance, requires members to consider in their risk assessments the techniques developed by relevant international organizations; and WTO panels, and the AB have an express mandate to consider international standards as indicating credible scientific opinions regarding environmental and health hazards,[96] while investment arbitral panels employ similar argumentation in the absence of any similar provision governing the required scientific bases of the justifiable exercise of host states' police powers.

To bring a concrete case, the *Philip Morris* v. *Uruguay* investment arbitration serves here as a stark example for such a reasoning, which featured a challenge against Uruguay's plain packaging measure for tobacco products (TPP). In the host state's view, this measure was a legitimate regulation for protecting public health and relied on the WHO Framework Convention on Tobacco Control to justify the reasonable nature of its policy in the light of public health research. The Convention establishes global standards for national tobacco control policies, [97] and is known for being based on 'the best available scientific evidence'.[98] The tribunal attached great evidentiary weight[99] to the submissions of expert organizations and to the fact that Uruguay complied with the

[94]P. Allott, 'Interpretation - An Exact Art', in A. Bianchi, D. Peat and M. Windsor (eds.), *Interpretation in International Law* (2015), 373, at 384.

[95]E.g., *Australia – Certain Measures concerning Trademarks, Geographical Indications and other Plain Packaging Requirements applicable to Tobacco Products and Packaging*, Report of the Panel, WT/DS435/R (Honduras), WT/DS441/R (Dominican Republic), WT/DS458/R (Cuba), and WT/DS467/R (Indonesia), 28 June 2018, para. 7.330; *Philip Morris Brands Sarl, Philip Morris Products SA and Abal Hermanos SA v. Oriental Republic of Uruguay,* ICSID Case No. ARB/10/7, Award of 8 July 2016, para. 392.

[96]See, e.g., *U.S. – Animals*, Report of the Panel, WT/DS447/R, 24 July 2015.

[97]L. Gruszczynski and M. Melillo, 'The FCTC Dilemma on Heated Tobacco Products', (2020) 16 *Globalization and Health* 1, 2.

[98]*U.S. – Clove cigarettes*, Report of the Panel, WT/DS406/R, 2 September 2011, para. 7.230.

[99]*Philip Morris Brands Sarl, Philip Morris Products SA and Abal Hermanos SA v. Oriental Republic of Uruguay*, ICSID Case No. ARB/10/7, Award of 8 July 2016, paras. 391–394.

Convention, although not as a matter of law but as reliable scientific proof of the efficacy of TPP in reducing tobacco-related health risks. On these premises, the panel deemed compliance with the Convention as persuasive proof that the TPP had a sound scientific basis.

In this scenario, judicial bodies in essence reason using legal rationality, because the authority of the respective scientific standard is detached from the epistemic authority of science included in the document. The persuasive force attached to the scientific knowledge reflected in international standards, in fact, stems from the perceived prestige, authority and international standing of the issuing organization. The credibility of such scientific positions for adjudicators and the relevant public is rooted in the fact that such standards represent 'negotiated science',[100] standards agreed upon by many stakeholders irrespective of the parties' legal conflict. As a result, an undoubted advantage of employing such legalistic yardsticks lies in relieving adjudicators from becoming ensnared in a substantive analysis of rival scientific evidence. This form of reasoning functions as a checklist, which non-expert judges can comfortably apply in their inquiry.

4.3.2 Regulatory trends

International regulatory trends may also provide persuasive benchmarks to identify genuine scientific positions concerning environmental or health risks. The *Chemtura* decision showcases this mode of adjudicatory reasoning. The dispute was brought to an investment tribunal to invalidate Canada's ban on lindane, which was imposed due to its risks to human health. The tribunal noted that '[i]rrespective of the state of the science'[101] on the harmful potential of the chemical, it attached great weight to the fact that 20 states, as well as the European Union, had already banned or restricted its use, and went on to find the Canadian ban lawful.[102] The panel also cited several multilateral environmental treaty regimes, which all regarded lindane as a harmful substance,[103] to justify its finding that Canada acted in good faith while banning the chemical with reference to its health hazards. This reasoning method also stems from legal logic, as the convincing force attached to law-maker's choices on applicable risks can be traced back to legal rationality.

4.3.3 Scrutinizing the procedural features of scientific knowledge production

An epistemically similar mode of reasoning is applied when judges check whether certain attributes of an idealized process of scientific knowledge production were fulfilled before adopting science-based regulatory decisions. This scientific due process-based[104] argumentation accepts those scientific results that were produced in a transparent and participatory procedure, preferably also requiring peer-review from inputs of regulatory science, as credible and legitimate.

The peer-review requirement is often seen as a useful procedural benchmark for pinpointing 'objective' scientific positions, both in legal commentary[105] and in international litigation.[106] Nevertheless, this criterion is not a failsafe method either. First, the objectivity of scientific research is established through a range of social practices and, thus, is a culturally embedded phenomenon, which may carry various meanings across different cultures.[107] Second, the peer

[100] S. Jasanoff, 'Serviceable Truths: Science for Action in Law and Policy', (2014) 93 *Texas Law Review* 1723, at 1741–3.

[101] *Chemtura Corporation v. Canada*, UNCITRAL, Award of 2 August 2010, para. 135.

[102] For the list of countries banning the lindane see ibid.

[103] Ibid., paras. 135–137.

[104] C. Lévesque, 'Science in the Hands of International Investment Tribunals: A Case for "Scientific Due Process"', (2009) 20 *Finnish Yearbook of International Law* 259.

[105] M. A. Orellana, 'The Role of Science in Investment Arbitrations Concerning Public Health and the Environment', (2007) 17 *Yearbook of International Environmental Law* 48, 72; see Lévesque, *supra* note 104, at 20; J. E. Vinuales, *Foreign Investment and the Environment in International Law* (2012), 378.

[106] *Methanex Corporation v. USA*, UNCITRAL, Final Award of 3 August 2005, Part III - Chapter A -51, para. 101.

[107] S. Jasanoff, 'The Practices of Objectivity in Regulatory Science', in C. Camic, N. Gross and M. Lamont (eds.), *Social Knowledge in the Making* (2011), 307, at 312–17.

review process has its pitfalls, such as personal and systematic bias favouring accomplished scientists or methods in line with the reviewer's own preference,[108] or even intentional fraud and plagiarism. Scientists have a more realistic account of what peer-review can actually deliver, inasmuch as it '*per se* provides only a minimal assurance of quality, and that the public perception of peer review, as a stamp of credibility, is far from the truth'.[109] In light of this, it is more appropriate to consider peer-review as a necessary, though not sufficient, benchmark for scrutinizing the integrity of scientific results to be accepted in a litigious context.

4.3.4 Applying legal doctrines rigidly in the face of uncertain science

Uncertainty, although it is by no means alien to law,[110] seems to be a disruptive force in environmental adjudication.[111] Scientifically untrained adjudicators often deem uncertain and probabilistic evidence as unfit to meet evidentiary requirements and may find it hard to become *ascertained* of the facts of the case based on *uncertain* and probabilistic data. As a result, international forums occasionally replace a science-based inquiry in their fact-finding with a legalistic reasoning. This occurs when courts construe scientific uncertainty as an insurmountable obstacle, frustrating a meaningful judicial analysis,[112] decide on science-heavy issues without evaluating party-submitted scientific evidence,[113] or provide only a rough and opaque 'overall' assessment of the expert opinions.[114] International judges sometimes also ponder on the non-justiciability of science-heavy legal issues,[115] or insist on simplifying complexity to fit the law's expectations and dismiss scientific causal proof for failing to meet causal doctrines in law or high evidentiary standards.[116]

In all these cases, judicial reasoners essentially place legal authority over scientific rationality. The overarching weakness of such argumentation is that they commit epistemic trespass and erode the factual accuracy of their decisions.

4.3.5 Satisfying law's need for certainty through legal constructs

However, not every legal argumentation style repudiates scientific knowledge. Legal logic can also validate solutions that adjust traditional legal doctrines to the uncertainties of scientific input. In contrast to 'judicial paralysis' in the face of uncertain scientific results, one may also find judicial solutions that deem relevant fact-intensive questions as amenable to judicial appraisal, even if the underlying facts are ambiguous. The *Gold Reserve* v. *Venezuela* tribunal, for instance, although

[108]S. Jasanoff, *The Fifth Branch* (1990), 61–79.

[109]C. Jennings, 'Quality and Value: The True Purpose of Peer Review', *Nature Blogs*, 2006, available at blogs.nature.com/peer-to-peer/2006/06/quality_and_value_the_true_pur.html (emphasis added).

[110]A. Garrido-Munoz, 'Managing Uncertainty: The International Court of Justice, "Objective Reasonableness" and the Judicial Function', (2017) 30 *Leiden Journal of International Law* 457, at 473.

[111]C. Smith, 'Policy Implications of Uncertainty', (2011) 369 *Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences* 4932; J. Peel, *Science and Risk Regulation in International Law* (2010), 378–79; L. Gruszczynski, *Regulating Health and Environmental Risks under WTO Law: A Critical Analysis of the SPS Agreement* (2010), 30–4.

[112]*Pulp Mills on the River Uruguay (Argentina v. Uruguay)*, Judgment of 20 April 2010, [2010] ICJ Rep. 14, paras. 257–259.

[113]*MOX Plant OSPAR Arbitration (Ireland v. UK)*, PCA Case No. 2001-03,, Award of 2 July 2003.

[114]J. E. Vinuales, 'Observations Sur Le Traitement Des Motifs Scientifiques Dans Le Contentieux Environmental International', in C. Matsumoto and R. Nollez-Goldbach (eds), *Les motifs non-juridiques des jugements internationaux. Actes de la 1ére journée de droit international de l'ENS* (2016), 113, at 114–15.

[115]*Whaling in the Antarctic (Australia v. Japan: New Zealand intervening)*, Judgment of 31 March 2014, [2014] ICJ Rep. 226 (Judge Sebutinde, Separate Opinion), para. 9; (Judge Owada, Dissenting Opinion), para. 24; (Judge Xue, Separate Opinion), para. 15.

[116]*Tatar v. Romania*, Judgment of 27 January 2009, [2009] ECHR, para.105; see *MOX Plant OSPAR Arbitration*, *supra* note 113, para. 164.; *Certain Activities Carried Out by Nicaragua in the Border Area (Consta Rica v. Nicaragua) and Construction of a Road in Costa Rica along the San Juan River (Nicaragua v. Costa Rica)*, Judgment of 16 December 2015, [2015] ICJ Rep. 665, para. 204.

noting the difficulties surrounding damage calculations, such as the presence of uncertain and 'equally legitimate' facts and valuation methods, continued to announce openly that 'the tribunal exercises its judgment in a reasoned manner'.[117] It therefore went on calculating the damages based on imprecise scientific data.

On other occasions, proceeding with the judicial analysis in the face of contested and contrasting party-submitted scientific evidence may be more problematic. In the compensation judgment in the *Certain Activities in the Area* case, for instance, the ICJ, instead of siding with either party's expert valuation of the ecological damage caused by the illegal activities of Nicaragua's troops on Costa Rica's territory, opted for conducting an 'overall assessment' of the parties' evidence to discern the quantum of compensation.[118] The Court famously came up with this sum through a 'corrected analysis',[119] where it did not provide any detailed explanations for its calculation. This solution has been met with criticism for not specifying the actual amount attached to the trees destroyed, and also for its inconsistent methodology concerning recovery periods.[120] And indeed, when a judgment suffers from salient gaps and contradictions in reflecting upon the parties' factual arguments and submissions, such an apparently cursory and arbitrary consideration of the scientific knowledge undermines the epistemic legitimacy of the reasoning.

The same criticism may be levelled against the judgment on reparations in *Armed Activities*, when the ICJ awarded a 'global sum' as reparation for the ecological resources looted and exploited by Ugandan forces. Even though the Court was furnished with independent expert evidence in the case, the calculation of the sum was not transparent and was not linked to any specific detail provided by the expert report, but it asserted it was 'within the range of possibilities indicated by the evidence, and taking into account equitable considerations'. [121]

An additional legalistic technique is provided by legal presumptions, which enable courts to render a decision despite infinitely ambiguous scientific data. Presumptions create a relevant connection between two facts for *the legal analysis purposes*, even if the pertinent scientific facts explicitly fall short of *proving* such a connection, scientifically speaking. Applying presumptions can be a particularly important tool in establishing liability for environmental harm or health injury, where the causal proof is virtually always burdened with scientific uncertainty. In *Fadeyeva* v. *Russia*, the ECtHR crafted a presumption of causality with respect to health injuries, when toxic pollution significantly exceeded domestic safety levels.[122] In the material case, the applicant experienced air pollution 20 to 50 times higher than the maximum permissible limits under domestic law, and medical reports confirmed a roughly three-fold increase in respiratory diseases among children living in the area.[123] Importantly, however, the expert opinion produced by the applicant could not substantiate any causal link between the pollution and her specific illness.[124] Nevertheless, via applying a presumption, the ECtHR found causality established, and hence a violation of the applicant's right to privacy.

Presumptions are only legitimate from an epistemic point of view if this tool does not replace scientific authority, available in the pertinent case, with legal logic. This requires, specifically, that judges must first attempt to engage with scientific evidence substantively, and only if that was not possible, due to the nature of scientific facts, should they take recourse to purely legal reasoning.

[117] *Gold Reserve Inc. v. Bolivarian Republic of Venezuela*, ICSID Case No. ARB(AF)/09/1, Award of 22 September 2014, para. 686.

[118] *Certain Activities in the Area (Costa Rica v. Nicaragua)*, Compensation, Judgment of 2 February 2018, [2018] ICJ Rep. 15, para. 78.

[119] Ibid., para. 86.

[120] Y. Tanaka, 'Temporal Elements in the Valuation of Environmental Damage: Reflections on the Costa Rica v. Nicaragua Compensation Case before the International Court of Justice', (2021) 90 *Nordic Journal of International Law* 257, at 269, 276.

[121] *Armed Activities on the Territory of the Congo (Democratic Republic of the Congo v. Uganda,* Reparations, Judgement of 9 February 2022, [2022] ICJ Rep. 13, para. 365.

[122] *Fadeyeva v. Russia*, Decision of 9 June 2005, [2005] ECHR, paras. 87–88.

[123] Ibid., para. 15.

[124] Ibid., para. 80.

Otherwise, presumptions could be (ab)used to create legally appreciable links, even if scientific knowledge expressly refutes such connections. Notably, in *Fadeyeva,* the ECtHR also only invoked a presumption in order to complement 'a very strong combination of indirect evidence', as it lacked sufficient direct scientific proof on the causal relations of the applicant's health impairment.[125] Such a presumption therefore duly observes epistemic legitimacy.

4.3.6 Impact on the legitimacy of reasoning

Legalistic reasoning is advantageous because adjudicators have this tool under their full epistemic command and thus can comfortably apply it when crafting their judgments. Even though the yardsticks based on legal rationality could ultimately be traced back to scientific knowledge, their application in the reasoning does not necessitate scientific competence from the court, as judges do not need to understand the subject-matter of the scientific controversy to apply presumptions, international standards or other legal constructs in the dispute. This reasoning method also secures epistemic non-arbitrariness, as it does not necessitate passing legal judgment on the veracity of scientific knowledge claims.

Legal logic and rationality may sometimes legitimately dominate the reasoning, even if the dispute was initially heavily argued with reference to competing scientific interpretations. The *Waters of the Silala* is a case in point. Both Chile and Bolivia had disagreed on the facts as to the transboundary nature of the Silala for more than 20 years before the Court's proceedings, and commissioned expert reports to prove their scientific positions before it. The language of the judgment, however, was completely devoid of scientific references. The reason for that lies in Bolivia's abrupt change in its position during the proceedings, whereby it came to agree with Chile on several respects.[126] The ICJ, on these bases, moved to find that, due to the parties' agreement, the majority of the claims no longer had any object. Given that the Court de-scientized its reasoning to reflect the emerging consensus between the parties, including the scientific questions too, the purely legal reasoning appears to be an epistemically adequate and legitimate approach.[127]

However, legal reasoning techniques are sometimes an explicit substitute for a scientific inquiry in the proceedings. When courts craft a purely legalistic reasoning to 'hid[e] behind legal reasoning';[128] that is, they appeal to legal logic *in lieu* of or in clear contradiction to the available scientific knowledge, they erode the factual accuracy of decisions and do not respect the cognitive authority of science. However, purely legal argumentative tools may still be appropriate techniques as complementary means of justification when scientific benchmarks are absent or insufficient. If, for instance, despite thorough scientific fact-finding, respective scientific input remains too uncertain to provide a definitive answer to the question at hand, crafting legalistic reasoning can be the best available argumentative option.

4.4 'Hybrid' reasoning

This taxonomy identifies another category of reasoning, which is akin to legalistic argumentation, though it forms a separate style due to its epistemic characteristics. This argumentative style is dubbed 'hybrid' reasoning here, because it is built around notions that are present in both the legal

[125]Ibid., para. 88.

[126]*Case Concerning the Dispute over the Status and Use of the Waters of the Silala (Chile v. Bolivia)*, Judgment of 1 December 2022, [2022] ICJ.

[127]Note, however, that some commentators criticize the Court for affording too extensive a reading to the parties' alleged agreements while glossing over some divergences in their opinions. See B. Salas Kantor and E. Zavala, 'The Silala Case: Was Justice Served?', *EJIl Talk!*, 9 December 2022, available at www.ejiltalk.org/the-silala-case-was-justice-served/?utm_source=mailpoet&utm_medium=email&utm_campaign=ejil-talk-newsletter-post-title_2. If the reminaing divergences rest upon competing scientific knowledge claims, the argumentative path of the Court could indeed be criticized for being harmful to the epistemic legitimacy of the reasoning.

[128]See D'Aspremont and Mbengue, *supra* note 10, at 253.

and the scientific discipline, and thereby bridge the two epistemic realms. The hybrid nature of such concepts denotes that their scientific and legal character are closely entangled with each other.[129] Concepts such as reasonableness, coherence and consistency are apt examples of notions that are relevant for both the legal and the scientific inquiry, although they carry slightly different meanings in the two realms. As will be explained below, these are robust enough to maintain coherence across different fields of knowledge in the necessary co-operation between science and law in an adjudicatory context. As such, hybrid concepts can satisfy the informational requirements of both social worlds.[130]

Hybrid notions often provide bases for judicial tests appraising the scientific soundness, and therefore the legality of, risk assessment decisions and other science-based legal measures in the context of adjudicatory reviews. The judicial scrutiny in such cases typically zeroes in on whether the justifications provided by the primary decision-maker for the science-based measure can be deemed 'reasonable', 'coherent' or 'consistent'. From an epistemic point of view, common to these notions is that they enable judicial reasoners to answer legal questions through combining evidence from the scientific and the legal disciplines. In this sense, these concepts constitute points of translation between the scientific and legal inquiry by marking legally appreciable dimensions of scientific notions. Interrogating the reasonableness, coherence or consistency of science-based decisions resembles legalistic reasoning, inasmuch as legally-trained reasoners can comfortably interpret these notions and draw authoritative inferences as to their main requirements by using legal logic. Concepts such as reasonableness and coherence[131] are fundamental concepts in law and legal reasoning,[132] expounding which are essential to exercising legal judgment.[133] At the same time, to determine what counts as 'reasonable' under the given circumstances cannot be established without having due regard to the scientific meaning of the notion.[134] In other words, judges should engage closely with scientific evidence when they formulate their own reading of 'reasonableness' and apply this (essentially legal) notion to (scientific) facts.

4.4.1 Illustration from international case law

The analysis of the ICJ in the *Whaling in the Antarctic* case presents an apt example of hybrid reasoning. The Court had to rule whether Japan's whaling programme complied with the special permit procedure of the International Convention of the Regulation of Whaling (ICRW), which allowed state parties to authorize their nationals to kill and take whales 'for purposes of scientific research'. The Court announced the reasonableness test to be an objective standard of review. It refused to define what 'scientific research' meant under the provision and equally refrained from basing its argumentation directly on those features of 'scientific research' that were submitted by the parties' experts. Instead, the Court deemed any research programme to be conducted 'for purposes of scientific research' within the meaning of the ICRW, where 'the programme's design and implementation … were … reasonable in relation to achieving its stated objectives'.[135]

[129]To describe these argumentative techniques, this article coined the term 'hybrid' reasoning, to intentionally invite connotations from the field of epistemology and Science and Technology Studies (STS) studies. For an account on 'hybridized' questions describing similar epistemic phenomena see Ballantyne, *supra* note 41, at 372; B. Latour, *We Have Never Been Modern* (1993), 3. The term 'hybrid' has also been used by Bruno Latour in STS literature to describe constructs in which the scientific and the social aspects are inextricably entangled with each other.

[130]S. Leigh Star and J. R. Griesemer, 'Institutional Ecology, "Translations" and Boundary Objects: Amateurs and Professionals in Berkeley's Museum of Vertebrate Zoology, 1907-39', (1989) 19 *Social Studies of Science* 387, 393.

[131]A. Amaya, 'Coherence, Evidence, and Legal Proof', (2013) 19 *Legal Theory* 1. See also J. G. Devaney, 'A Coherence Framework for Fact-Finding before the International Court of Justice', (2023) *Leiden Journal of International Law*.

[132]A. Peczenik, *On Law and Reason* (2009), 131.

[133]See A. Garrido-Munoz, *supra* note 110.

[134]On the role and meaning of reasonableness in the scientific discipline see A. Franklin, *Can That Be Right?: Essays on Experiment, Evidence, and Science* (1999), vol. 199, 283.

[135]See *Whaling in the Antarctic*, *supra* note 115, para. 67.

Such reasoning saved the Court from judging the scientific merits of the whaling programme and decoupled the Court's analysis from being based solely on scientific epistemic rationality, as advocated by the parties in their submissions. The reasonableness assessment ensured that the judicial task was not reduced to a simple choice between the parties' conflicting scientific narratives, or to afford deference to state decision-makers on defining 'scientific research'.[136]

Moreover, such reasoning also made it possible for the Court to decide the contentious issue in a substantive manner without, however, subordinating scientific authority to law's authority. This feature of the reasonableness test is beneficial from an epistemic legitimacy perspective, which has, however, been under-appreciated in the scholarly commentary on the case.[137] The judgment has been criticized for not defining 'scientific research', even though party-submitted expert evidence offered competing conceptualizations of the term.[138] Importantly, however, from an epistemic point of view, by refraining from defining what 'science' meant under international law, the Court, in fact, ensured adequate respect for the equal cognitive authority of science in its judicial assessment, and thereby observed epistemic non-arbitrariness.

4.4.2 Impact on the legitimacy of reasoning

From the perspectives of epistemic legitimacy, hybrid reasoning is beneficial because it enables judges to speak the language of a legalistic assessment while also reflecting on the underlying science. Judges can formulate their own reading of these concepts, and, in this way, expert positions do not dictate the outcome of the court's inquiry, although expert input remains inescapably relevant. Notably, when the ICJ applied the reasonableness test to the facts, it touched upon several features that the party-submitted expert evidence described as constitutive elements of the 'scientific' method, without adopting either side's narrative in its entirety.[139] This aptly signals that the application of hybrid argumentative tests remains closely tied to the scientific aspects of disputes, and thereby ensures a close judicial engagement with scientific arguments and evidence.

Furthermore, interpreting hybrid concepts does not prompt, nor does it allow epistemic trespassing.[140] Judges using hybrid notions should only decide on the legally appreciable features of science-based reasoning, such as its reasonable, coherent or consistent nature, and do not need to act as 'super-experts'. This mode of reasoning similarly does not necessitate deciding whether the scientific claim is '*the*' single correct answer to the scientific controversy, since reviewing the reasonableness of a science-based position does not compel judges to conduct a *de novo* appraisal as to the correct interpretation of the evidence.[141] Ruling on these hybrid qualities says nothing about the scientific veracity or the robustness of the scientific findings put forth in the science-based opinion under review.

Importantly, judging the reasonableness and coherence from a scientific as well as a legal point of view remain distinct processes, carried out using different methodologies,[142] rules and conventions, informed by distinct fields of expertise. For example, assessing the reasonableness of

[136]On the role and functioning of the reasonableness test in the context of epistemic deference granted by international courts see E. Shirlow, *Judging at the Interface - Deference to State Decision-Making Authority in International Adjudication* (2021), 174–5.

[137]See, e.g., M. M. Mbengue and R. Das, 'The ICJ's Engagement with Science: To Interpret or Not to Interpret?', (2015) 6 *Journal of International Dispute Settlement* 568; B. Gogarty and P. Lawrence, 'The ICJ Whaling Case: Missed Opportunity to Advance the Rule of Law in Resolving Science-Related Disputes in Global Commons?', (2016) 77 *ZaöRV* 161.

[138]See Gogarty and Lawrence, *supra* note 137.

[139]See *Whaling in the Antarctic*, *supra* note 115, paras. 147–222.

[140]Ballantyne suggests that epistemic trespassing can be prevented by focusing on non-hybridized sub-aspect of interdisciplinary (i.e., hybridized) questions that can be answered by only one of the disciplines involved. See Ballantyne, *supra* note 41, at 375–6.

[141]*The Government of Sudan/The Sudan People's Liberation Movement/Army (Abyei Arbitration)*, PCA Case No. 2008-07, Final Award of 22 July 2009, para. 537.

[142]Ibid., para. 406.

a research scheme requires expertise in statistics, whereas evaluating the legal reasonableness of a research project, as occurred in the *Whaling in the Antarctic* case, rests upon abstract conceptual thinking and inferential reasoning. This also means that a hybrid method of argumentation enables judicial reasoners to tread carefully along the border between legal and scientific appraisal, and not to substitute the experts' assessment with their own view on the validity of scientific knowledge claims. Overall, hybrid concepts are located on the law-science interface and, hence, constitute 'boundary objects'[143] of scientific and judicial reasoning, through which the scientific merit of an expert input can be translated into legal determination. Differently put, these notions provide windows of evaluation, enabling judges to assess whether a science-based legal position can be accepted for purposes of the legal analysis, without interrogating the scientific veracity of respective scientific claims.

5. Parameters for choosing the epistemically appropriate reasoning style

As it follows from the above, all four techniques have epistemically legitimate forms that could be appropriate and legitimate reasoning styles under certain circumstances. The legitimate argumentative space, shown in Figure 1, comprises a wide array of scientific, legalistic, hybrid, and intuitive reasoning techniques. The upper limit of acceptable and feasible judicial engagement with scientific rationality is marked by the terrain of scientific and hybrid reasoning. To observe the lower limit of epistemically legitimate reasoning, judicial reasoners ought not to contradict or replace available scientific knowledge with a de-scientized inquiry, and hence, downplay the role of science in the reasoning to an excessive extent. At the same time, not every epistemically legitimate form of reasoning requires a science-heavy argumentation from the courts. Intuitive and legalistic reasoning remain necessary and useful constituents of the adjudicatory reasoning toolkit. The key question therefore lies in *when* to have recourse to a particular argumentative technique to observe epistemic legitimacy. The most appropriate style may vary from case to case, depending upon many circumstances, which are discussed below.

5.1 Internal epistemic capacities of the judicial body

The extent to which judges can accord a high profile to scientific knowledge in their reasoning in an epistemically legitimate way depends firstly on the epistemic capacities of their respective institution. This is contingent upon two main factors: the scientific fact-finding powers granted to the judicial body and the court's willingness to utilize such powers; and the ability of judges to exert cognitive control over the scientific input received. If these two preconditions are met, adjudicators can legitimately enhance the science-intensity of their reasoning by basing their argumentation on scientific rationality or on hybrid notions.

Whenever extensive scientific epistemic support is guaranteed in the institutional set-up of the judicial body, judges should be encouraged to engage with scientific knowledge in a thorough and meaningful way. A detailed reflection on the scientific dimensions in a judgment is only possible if judges are willing to avail themselves of their existing fact-finding powers, especially those that allow for vesting the bench with impartial expertise, such as appointing *ex curia* experts or expert arbitrators. However, the fact-finding powers of a judicial body alone are not decisive for the legitimacy of the judicial decision reached. Expert input needs to be scrutinized, interpreted, contextualized, and ultimately integrated in the reasoning in an epistemically non-arbitrary way by legally-trained judges. This points to the importance of adjudicatory readiness and a willingness not to shy away from accommodating scientific rationality in the judicial findings.

[143]See Leigh Star and Griesemer, *supra* note 130, at 393.

5.2 Practical feasibility in the litigious process

Thorough evidentiary proceedings are lengthy and costly, and hence, may not be feasible in a given dispute due to financial constraints or the time pressure under which adjudicators and the parties operate in litigation. On such occasions, relying on scientific rationality is often not possible for the courts, but legal or intuitive benchmarks may provide satisfactory argumentation. Moreover, there will be several instances when uncertainty and ambiguity in the sciences will be insurmountable and pervasive, which precludes basing the reasoning on scientific rationality. In such cases, adjudicators can craft legalistic benchmarks to bridge the gap between uncertain facts and law's need for certainty. Alternatively, courts may have recourse to intuitive reasoning in order to craft a legally legitimate and persuasive reasoning.

5.3 The different role science plays in the fabric of legal rules

The legitimate role of science cannot be defined *in abstracto*, as it heavily depends not only on the facts, but also on the legal context of each case. Science in the courtroom should be treated as a multi-dimensional factor. Scientific knowledge, which enters the adjudicatory process, is not a monolithic concept,[144] as it covers a host of specialized fields of knowledge, which use their own methodologies. Various sources of scientific uncertainty are also heterogeneous in terms of their nature and pervasiveness. Finally, the role of science is also not uniform across different legal contexts.

Scientific knowledge may play diverse roles in the construction of legal rules. In certain cases, science is fed into the adjudicatory process to answer binary questions, typically concerning questions of scientific validity, such as whether a certain piece of expert evidence is scientifically sound enough for being accepted for the purposes of the legal inquiry.[145] Relevant examples may be drawn from the law of evidence and causal inquiry, where the scientific legitimacy of an expert evidence impacts perhaps most directly the legal legitimacy of that evidence, i.e., its acceptability for the adjudicatory process. In such cases, deferring to expert assessments, and thereby reasoning with scientific rationality, may yield the most robust argumentative style. This is because the ultimate question, whether to accept a certain piece of scientific evidence to make legal findings, cannot be decided authoritatively and legitimately without having recourse to scientific epistemic authority.

However, in other scenarios, the scientific dilemma put before legal adjudicators combines scientific and socio-legal aspects. The legal question in such cases mixes scientific data with normative value judgments. Such questions that combine a scientific 'core' with a normative 'cloak' abound in science-intensive adjudication. A salient example lies in the judicial review of risk assessment decisions that avowedly constitute normative judgments, which are not dictated, but informed by scientific knowledge. In these instances, judges in fact scrutinize whether primary decision-makers have discharged their mandate properly in appraising and managing environmental and health risks by providing explanations that fully account for the possible interpretations of underlying data.[146] By reviewing the logical coherence, reasonableness or consistency of the primary decision-makers' reasoning, judges can assume an 'informational catalyst'[147] function to 'prompt responsible actors to engage in effective problem solving'.[148] Due

[144]See Fisher, *supra* note 66, at 750–1.

[145]For a categorization comprising cause, scale and spectrum tests see E. Lees and T. Paloniitty, '"Science" in Court - The Importance of Specificity', in E. Lees, M. Eliantonio and T. Paloniitty (eds.), *EU Environmental Principles and Scientific Uncertainty before National Courts* (2023), 9.

[146]See in the WTO context *U.S. – Safeguard Measures on Imports of Fresh, Chilled or Frozen Lamb from New Zealand*, Report of the Appellate Body, WT/DS177/AB/R, 1 May 2001, para. 1086.

[147]E. Vos, 'The European Court of Justice in the Face of Scientific Uncertainty and Complexity', in M. Dawson, B. De Witte and E. Muir (eds.), *Judicial Activism at the European Court of Justice* (2013), 142, at 152.

[148]J. Scott and S. Sturm, 'Courts as Catalysts: Re-Thinking the Judicial Role in New Governance', (2007) 13 *Columbia Journal of European Law*, 565, at 575.

to the social, normative and altogether non-scientific dimensions implied in such disputes, outsourcing the judicial appraisal entirely to scientific experts and scientific rationality would yield an epistemically unsatisfactory result. Instead, such a configuration of scientific authority in the fabric of legal norms invites hybrid reasoning, where judges can fully account for the non-scientific aspects of a thorough and accountable decision-making process, while also taking relevant scientific input into account.

Simultaneously, certain legal rules contain express scientific legality criteria,[149] where scientific concepts are embedded in an elaborate legal text that clearly defines the role envisaged for scientific authority in the operation of the normative rule. These legal contexts arguably attempt at 'taming' scientific knowledge, by delineating a more confined room for science in the fabric of legal rules. This scenario often involves crafting legal definitions for scientific constructs, such as 'scientific research' or 'scientific guidelines' by specifying what they ought to mean under the given legal context. When the legal dispute revolves around legal instruments containing such scientific legality criteria, adjudicators can easily apply grammatical-intuitive reasoning.

Finally, it is to be underlined that the different ways in which science functions in various legal contexts imply different legal relevance for scientific knowledge, which in turn invites different styles of reasoning. Overall, securing epistemic legitimacy for judgments calls for taking a nuanced judicial approach towards scientific authority in the judicial reasoning.

6. Conclusions

The above analysis illustrated that there are several epistemically legitimate ways to reflect on scientific rationality from an adjudicatory perspective. Some invite closer reflection on scientific cognitive authority; others can be performed with a looser engagement with scientific knowledge, as in such cases the underlying rationality remains essentially legal or intuitive in nature. Hybrid concepts yield judicial tests that interrogate the legally appreciable features of scientific notions.

It must be emphasized that the proposition here was not that using *more* science would necessarily result in better reasoned and, thus, epistemically more legitimate judgments. Appealing to scientific knowledge by legally-trained judges can be just as vulnerable to legitimacy challenges as eliminating the scientific profile of disputes from adjudicatory justifications. Instead, this article sought to offer guidelines for adjudicators as to how they can invoke various types of epistemic rationalities in scientific disputes in a way that also observes epistemic legitimacy. This piece also argued that a common prerequisite for the legitimate forms of applying various rationalities in the reasoning is that judges discharge their epistemic duty to develop an overall understanding of the scientific dimensions of the legal dilemma and, therefore, maintain cognitive control over the scientific aspects of the dispute resolution. This allows scientific authority to be relied on in the judicial decision in an epistemically non-arbitrary way, on the one hand, and, on the other, for identifying those instances when reasoning using non-scientific rationality can be justified from an epistemic legitimacy point of view.

This article also showed that the relationship between scientific authority and legal legitimacy is not unidirectional but more complex. Having recourse to scientific input in adjudication not only scaffolds the legitimacy of decisions, but also raises dilemmas as to how scientific authority can adequately be incorporated in the judicial assessment. If judges were to neglect important differences between modalities of crafting epistemically legitimate justifications for accepting or refuting science-based knowledge claims, their decisions would become inaccurate and vulnerable to legitimacy challenges. Nevertheless, should judges respect the conditions for epistemic legitimacy, they become able to harness the cognitive authority of science to buttress the convincing force of their findings.

[149]See Pauwelyn, *supra* note 14, at 235.

Persuasive legal decisions are a co-production of legal and scientific rationality, and interdisciplinary co-operation between different rationalities in the courtroom should be managed by legally-trained reasoners. Achieving the ideal, of epistemically legitimate judicial decisions, no doubt poses a demanding and epistemically arduous task for international adjudicators. However, in times of the undeniable and sometimes even disruptive grip of scientific and technological advancements on all aspects of human life and the social order, no other options may be left for international forums than to develop their own approach for securing a direct, more open, and epistemically sound engagement with scientific authority.

Cite this article: Sulyok K (2024). Science, epistemology and legitimacy in environmental disputes – The epistemically legitimate judicial argumentative space. *Leiden Journal of International Law* **37**, 139–166. https://doi.org/10.1017/S0922156523000559