Verification Regimes: Challenges of Knowing and Deciding within Knowledge Infrastructures

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Abstract:

Knowledge is an integral part of verification regimes. Knowledge cannot be seen as pure factual truth that arises directly from data, but has to be analysed as aggregated interpretations that stem from technical data and political judgement as well. These interpretations are related to specific, verification regime-related epistemic communities; however, such interpretations are typically unquestioned if the overall regime works well. As the produced knowledge is at the very basis of decision-making, its quality and the production process beyond the technical realm must be of interest: technologies used for knowledge production are embedded in wide-ranging production chains – so-called knowledge infrastructures. These infrastructures are institutions that regulate and organise the production, distribution and use of knowledge by setting gathering and processing standards. Within these infrastructures, practitioners interpret the incoming flow of information through constant interaction. As the practitioners shape not only the knowledge but also the infrastructure itself, a systematic epistemic analysis of knowledge infrastructures and key actors therein, such as the IAEA, can provide a reflexive element to uncover biases and blind spots (also referred to as non-knowledge). Our contribution aims at elucidating the challenges of knowing and deciding within knowledge infrastructures, especially concerning the influx of new kinds of information and constantly evolving verification technologies.

Introduction

This paper is a preliminary result of ongoing interdisciplinary research on new innovative approaches to nuclear verification in the interdisciplinary project "VeSPoTec" [1]. In the project and consequently in this paper, the authors focus on knowledge production in nuclear verification regimes. The deeper understanding can contribute to the development of tools and approaches to future nuclear verification scenarios as well as to improving the credibility, legitimacy and effectiveness of nuclear verification regimes, and ultimately contribute to improved international confidence-building measures. In accordance with the IAEA's Symposium on International Safeguards 2022 theme, our interdisciplinary approach could provide a valuable asset for "Reflecting on the Past and Anticipating the Future". The goal of such an analysis is to identify, inter alia, (future) challenges of knowing and deciding within nuclear verification regimes by understanding the complex interweaving of material artefacts (e.g. databases, models, measurement recordings) and social as well as political dynamics. The authors assume that knowledge is not only composed of a collection of data and information, but is to be understood as a social practice that depends on various interacting aspects. These aspects of knowledge production and knowledge creation form a network – the knowledge infrastructure – which consists of actors (e.g. politicians, scientists, activists, institutions such as international organisations or research centres) and material artefacts. Knowledge infrastructures are neither static nor homogeneous, but are in a constant state of change through conflict and adaptation. This contribution serves as a first conceptualisation of a systematic analysis of knowledge infrastructures in verification regimes. The authors first present their initial exploratory research and their approach to the topic of "knowledge production". The paper then goes on to examine knowledge infrastructures in more detail, finally identifies knowledge infrastructures in the context of nuclear verification as research desideratum and outlines first steps for subsequent research.

Our approach partly overlaps with knowledge management in that we also look at different actors and knowledge carriers. But in contrast to knowledge management approaches which focus more on how knowledge can be effectively captured and transferred within and between organisations, an epistemic analysis aims at a deep understanding of the broad array of societal and epistemic factors [2] influencing the *production* of knowledge that is relevant for decision-making in verification contexts.

Understanding Limiting Factors in Knowledge Production: From an Exploratory Analysis of Verification Regimes to Complex Knowledge Infrastructures

At the beginning of our research in the project "VeSPoTec", the research consortium approached the subject of nuclear verification by analysing former and current verification regimes under four different disciplinary lenses to identify (I) normative-ideational-institutional factors, (II) geopolitical and strategic factors, (III) technical factors and technological frameworks, and finally (IV) knowledge production as influences on the design, implementation and contestation of verification mechanisms. Our joint initial findings are based on an exploratory but comprehensive review of literature and documents: In an inductive research approach, a set of more than 50 verification cases has been examined through the aforementioned disciplinary lenses. The cases selected for study can be categorised as follows: verification of peaceful uses (e.g., JCPoA), arms control (e.g., New START), verification of dismantlement and disarmament of nuclear weapons (e.g., the IAEA in South Africa), and other verification activities.

Since the authors' focus is on knowledge production specifically, they have initially examined verification regimes for the role of the production of knowledge within such regimes and, in particular, the role of non-knowledge. Approaching the broad topic of knowledge production via non-knowledge allows to make limits of knowledge production transparent and thereby allows getting a valuable starting point for an analysis. Non-knowledge is essential to verification as it is a potential source of uncertainty and risk. In a further attempt to make knowledge production tangible, we searched for isolated socio-technical challenges of knowledge production within verification regimes. Doing so, we identified four limiting factors of knowledge production in nuclear verification regimes:

First, knowledge production is *restricted by technical limits*: Technical tools of data gathering must be (cost-) efficient *enough* to be applied in verification processes. Furthermore, technical data must be reliable and accurate *enough* to serve as a sound foundation for policy-making and confidence-building. Otherwise, the technology implementation can easily be contested by relevant stakeholders. Comprehensive and accurate verification is, however, potentially limited by the availability of appropriate technology. Technical limits can only be overcome by either the emergence of new technology, the use of technology developed specifically for this purpose, or the improvement of existing technology.

Second, knowledge production is *limited by regulatory frameworks*: While regulatory frameworks (e.g., international treaties) define the extent of what can be known – typically in the form of the precisely formulated treaty limitations and verification protocols – and thus a space in which knowledge can and may be produced, they thereby actively exclude possibilities of knowledge production outside this delineated space at the same time. Another regulatory limitation of knowledge production arises from the codification of current contexts and conditions in frameworks: Since frameworks represent a consensus that was reached and contractually fixed at a certain point in time and in a certain political context, rigid frameworks may not be able to reflect new (e.g. technical) developments like new unregulated launcher systems, creating exploitable gaps in the verification regime. In other words, regulatory frameworks provide States with a delimited space for the production of knowabilities and thus predictability and a sense of certainty in regard to the measures. Viewed like this, the production of *known unknowns* is permitted and tolerated although this comes with a certain amount of uncertainty – and potentially risk – about the reality outside the verifiable framework.

Third, knowledge production is *limited by the active maintenance of ignorance*: While data collection and knowledge production may lead to reduced risks and uncertainty, successful and universally accepted verification is not necessarily based on a vast and comprehensive exchange of data, information and knowledge alone. In many cases, a complete diffusion of knowledge would not only be impossible but also not desirable: a certain level of secrecy and knowledge limitation is often perceived as essential. The trade-off between comprehensiveness and secrecy is therefore a deciding factor for a State's decision to implement verification mechanisms or to contest it, as it poses the questions: is data good enough to build confidence; is it too intrusive and potentially harmful for the State?

Fourth, knowledge production is potentially *limited by the perception of objectivity or subjectivity*, and/or political factors: A verification regime may be contested when the perception prevails that the produced knowledge does not represent an objective "truth"

but is rather constructed under the influence of subjectivity and political factors ("bias"). Actors potentially understand the produced knowledge and the regime's tools of knowledge production as a possible strategic resource.

However, this heuristic of limiting factors cannot capture the complex dynamics of knowledge production as such, nor the interconnectedness of the challenges. To analyse knowledge production holistically, one needs to take into account the interweaving of – sometimes isolated – challenges from more disciplinary lenses as they are all part of knowledge production.

This interweaving of factors and challenges identified under different disciplinary lenses is perhaps most evident in the way technology and knowledge production are linked, but is also observable in the way international power relations influence the design of the processes that in turn produce knowledge. For instance, knowledge produced in verification procedures plays an active part in arms control policy, meaning that verification mechanisms are not only established based on such policies, but also have an effect on policy- and decision-making and are therefore strongly related to power and influence in international relations. Power and new (e.g., technical) ways of knowledge production influence each other both ways and are in a dynamic relation with each other. The concrete shape of knowledge production procedures can be essential in (or essentially influenced by) successful negotiations and bi- or international cooperation as verification can build a bridge for trust-building even between powers that deem themselves competitors. The exercise of power and trustworthy knowledge production in verification are hence heavily interlinked here. The institutional set-up of organisations such as the IAEA also influences verification activities and therefore knowledge production: personnel, diversity, socialisation etc. can all impact how knowledge is produced. Even the institutional set-up of an organisation itself is dependent on world views, power relations or the conception of the organisation's role in foreign policy, only to give some examples.

Hence, our identified challenges in knowledge production are necessarily connected with political and technical challenges identified under the disciplinary lenses as they all impact (the establishment of) nuclear verification regimes, are not logically separable and take place in a complex construct: the *knowledge infrastructure*. An infrastructure consists of a multitude of elements (actors, objects, processes, etc.) that shape and influence knowledge production, it sets standards and declares knowledge as legitimate, relevant or irrelevant.

There are some benefits to our infrastructure approach: understanding an infrastructure as a monolithic knowledge producing entity or observing only isolated parts of it, renders connected functions and dynamics of knowledge production invisible. Susan L. Star (1999) notes, referencing Bruno Latour and Emilie Hermant: "Study a city and neglect its sewers and power supplies (as many have), and you miss essential aspects of distributional justice and planning power" (p. 379). This observation is equally true when studying verification infrastructures and should therefore be of high importance: focusing on knowledge infrastructures allows deeper insights into the development and transformation process of knowledge generation. This opens up a perspective that helps to understand which epistemological structures and rules underlie a (functioning) verification regime. In other words, an analysis of knowledge infrastructures can help identify the sources, methods and standards of knowledge production that inform decision-making and policy-making. The infrastructural analysis can be used to make more reflective decisions and to make – previously invisible – weak points of an infrastructure transparent. This might prove useful in the construction and establishment of new verification approaches and regimes, and might help facilitate adjustments to new conditions such as the inclusion of emerging technologies or political disruptions.

Approaching Challenges of Knowing and Deciding within Knowledge Infrastructures Analytically

Knowledge production in the context of International Organisations (IOs), such as the IAEA, has already been in the focus of other social science research: IOs as actors with their own epistemic authorities, the influence of epistemic communities on IOs [3], and the relation between knowledge and the exercise of power in IOs have all been studied (Bueger 2015, pp. 1-2; Adler 1992). Yet, these studies have hardly explored how knowledge is actually produced in different "epistemic practices" (Bueger 2015, p. 1) in the context of knowledge infrastructures and "how validity and certainty are constructed" (Bueger 2015, p. 3).

In order to approach knowledge infrastructures methodologically and to make such a complex system more tangible in future research, it is helpful to make use of core aspects of the concept "epistemic infrastructure of global public policy" (Bandola-Gill et al., 2022). Originally used to examine global public policy-making through infrastructuring in the context of SDGs, the differentiation it contains can also be used to analyse different levels of knowledge production in knowledge infrastructures of nuclear verification. Accordingly, an infrastructure is divided into three different levels.

> *Materialities*: At the first level are the building blocks of the infrastructure. Materialities or, as we often call them, material artefacts consist of data, indicators, visualisations, reports, etc., which are used, for example, to measure and represent nuclear activities and risks. Materialities of an infrastructure are of analytical interest because they make certain phenomena or fields of interest visible (Star 1999). Investigating material artefacts within an infrastructure can potentially elucidate political and social challenges in knowledge production: a seemingly objective or neutral material artefact, such as a quantification tool, can be chosen based on political decisions or can construct categories relevant for political decisions where there would be none or different ones. This relates to "the question of whether and how values are inscribed into technical systems" (Star 1999, p. 388) and how this influences knowledge production. In this respect, materialities are not neutral or objective, but influence and are influenced by complex social, technical and political configurations.
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> *Linkages*: The second level focuses on the linkages within the infrastructure. These are the connections and networks by which the materialities are brought together. Networks of experts, such as epistemic communities (Haas 1992; 1997) or communities of practice (Wenger 1999) involved in the generation, dissemination and application of knowledge on nuclear issues through epistemic practices (Bueger 2015), play an important role at this level. The generation, dissemination and translation of knowledge is not homogeneous or consensual, but occurs through conflict and fragmentation. Analysing an infrastructure also comes with "surfacing invisible work" (Star 1999, p. 385), meaning making "work [that] goes unnoticed or is not formally recognized" (Star 1999, p. 386) visible. This unnoticed work could be essential in how knowledge within nuclear verification regimes is produced and should therefore be considered in a systematic analysis of knowledge infrastructures.
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> *Governing paradigms*: The governing paradigm is the overarching agenda, an overarching goal, towards which the knowledge infrastructure is aligned and simultaneously challenged. The governing paradigms are not immutable, but are subject to constant negotiation processes. Examples of this are multilateral agreements or transnational

initiatives. One paradigm that could be of interest is the quantification paradigm (Erkkilä et al. 2016; Davis, Fisher, Kingsbury & Engle Merry, 2012) within IOs such as the IAEA. Quantification governance is a governing paradigm that relies on numbers, data, and indicators to measure, compare and evaluate performance, progress and impact. Under the ambition of producing and using knowledge that is objective, transparent and comparable across different contexts and domains, it became "the central mode of knowing global problems" or, as Bandola-Gill (2022) put it, "politics of numbers" (p. 9). As a "site of co-production of knowledge and power" (Bandola-Gill 2022, p. 10), quantification can be seen as a way of exercising power and authority by classification, by fixing meanings, by setting standards, benchmarks, indices as well as targets that influence the behaviour and choices of various actors within verification regimes (Bandola-Gill 2022; Barnett & Finnemore 1999; Bueger 2015). This could also lead to producing non-knowledge or *blind spots*, as "[w]hat is measured, could be imagined and governed [...] setting limits to the political imagination" (Bandola-Gill 2022, p. 10). As Star (1999) put it, research on infrastructures could start by "identifying master narratives" (p. 384). Such a narrative "does not problematize diversity [... and] speaks unconsciously from the presumed center of things" (p. 384). One master narrative could be, as Anna Weichselbraun (2020) put it, the assumption of safeguards verification as an "unexciting technocratic project" (p. 121). This "appearance of depoliticization", as Barnett and Finnemore (1999, p. 708) mention, referencing Max Weber's work on bureaucratization, is deemed one essential source of an IO's authority. Finding the master narrative might uncover hidden biases in knowledge production and problematise underlying assumptions in nuclear verification regimes.

Based on these theoretical building blocks and first assumptions about the actors working in different parts of the nuclear verification infrastructure (e.g. analysts, inspectors, etc.) and their respective expertise and networks, conceptual and empirical research needs to focus on the following topics to further elaborate the notion of knowledge infrastructures in the context of verification regimes:

1. The actors' role within knowledge production in the nuclear verification infrastructure, including their epistemic practices and methods used to produce knowledge, and their experience with challenges and limitations associated with these practices and methods.
2. The actors' perceptions and knowledge of the materialities used in the nuclear verification infrastructure, including the data, indicators, visualisations, formalised processes and reports used to measure and represent nuclear activities and risks.
3. The actors' perspectives on the linkages within the nuclear verification infrastructure, including (their role in) networks of experts involved in the generation, dissemination, and application of knowledge on nuclear issues, and the conflicts and fragmentation associated with these networks.
4. The actors' (potentially hidden) assumptions of the various different governing paradigms of nuclear verification infrastructures, including the overarching goals and challenges that shape knowledge production and decision-making processes.
5. The actors' insights into how emerging technologies and political disruptions may impact the knowledge production and decision-making processes in the nuclear verification infrastructure.
6. The actors' suggestions for improving the knowledge production and decision-making processes in the nuclear verification infrastructure, and their ideas for innovative approaches to address the verification challenges.

Conclusion

The overall purpose of this contribution was to provide a heuristic and some theoretical building blocks for structuring and organising an epistemic analysis of knowledge infrastructures in the field of nuclear verification. The framework is intended to help further examine the ways in which knowledge is formed in this specific context and what challenges of knowing and deciding lay within knowledge infrastructures. Such a heuristic framework can be used in different ways: It can be used for a critical evaluation of existing knowledge infrastructures or for a comparative analysis of different infrastructures. It can also serve as the basis for subsequent interdisciplinary research that will delve deeper into the challenges and aims at innovative approaches to these verification challenges.

Until now, our ongoing research on the challenges of knowledge production in nuclear verification, as well as the construction of the heuristic, rely heavily on an exploratory review of literature and documents. Therefore, this article is not about addressing all relevant issues that influence or are important for analysing knowledge production in nuclear verification regimes. In our future research, we will consolidate the building blocks for a more generalised analysis of knowledge infrastructures on the one hand, and advance empirical analysis of knowledge infrastructures in selected verification regimes on the other.

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Footnotes

[1] *VeSPoTec – Verification in a complex and unpredictable world: social, political and technical processes:* VeSPoTec's mission is to build bridges between the natural and social sciences to strengthen and advance the knowledge on verification in the context of peace and conflict research. The centre aims to further advance the research field by taking an integrated interdisciplinary approach to nuclear verification processes in the context of non-proliferation, arms control and disarmament.

[2] Epistemic is a philosophical term that stems from epistemology, the theory of knowledge. Epistemology deals with questions such as "How do we know?" and "What makes our beliefs justified?".

[3] An epistemic community is defined as "a network of professionals with recognized expertise and competence in a particular domain and an authoritative claim to policy-relevant knowledge within that domain or issue-area" (Haas 1992, p. 3).

References

Adler, E. (1992). The emergence of cooperation: national epistemic communities and the international evolution of the idea of nuclear arms control. *International Organization*, 46(1), pp. 101–145. https://doi.org/10.1017/s0020818300001466

Bandola-Gill, J., Grek, S., Tichenor, M. (2022). Epistemic Infrastructures: SDGs and the Making of Global Public Policy. G*overning the Sustainable Development Goals.* Sustainable Development Goals Series. Palgrave Macmillan, Cham.

Bandola-Gill, J. (2023). Our common metrics? Our Common Agenda report and the epistemic infrastructure of the Sustainable Development Goals. *Global Policy*, 14 (Suppl. 2), pp. 8–12.

Barnett, M. N., & Finnemore, M. (1999). The Politics, Power, and Pathologies of International Organizations. *International Organization*, 53(4), pp. 699–732.

Bueger, C. (2015) Making Things Known: Epistemic Practices, the United Nations, and the Translation of Piracy. *International Political Sociology* (9), pp. 1–18.

Erkkilä, T., Peters, B. G., & Piironen, O. (2016). Politics of Comparative Quantification: The Case of Governance Metrics. *Journal of Comparative Policy Analysis: Research and Practice*, *18*(4), pp. 319–328. https://doi.org/10.1080/13876988.2016.1145871

Davis, K., Fisher, A., Kingsbury, B. & Engle Merry, S. (2012). *Governance by Indicators*. Oxford University Press. https://doi.org/10.1093/acprof:oso/9780199658244.001.0001

Haas, P. (1992). Introduction: Epistemic communities and international policy coordination. *International Organization, 46*(1), pp. 1-35.

Haas, P. (1997). Knowledge, power, and international policy coordination. Columbia, SC: Univ. of South Carolina Press (Studies in international relations).

Star, S. L. (1999). The Ethnography of Infrastructure. *American Behavioral Scientist*, 43(3), pp. 377–391.

Weichselbraun, A. (2020). From Accountants to Detectives: How Nuclear Safeguards Inspectors Make Knowledge at the International Atomic Energy Agency. *PoLAR: Political and Legal Anthropology Review*, Vol. 43, Number 1, pp. 120–135.

Wenger, E. (1999). Communities of Practice: Learning, Meaning, and Identity. Cambridge University Press.