A Toolbox for Studying the Global Politics of Science and Technology

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Abstract The growing preeminence of science and technology in today's world no longer fits into most existing analytical frameworks. Material elements, technical instruments, and scientific practices are intertwined with basically every aspect of global politics. Nevertheless, the discipline of International Relations (IR) as a whole tends to conceptualize this topic as an exogenous phenomenon. By adopting the notion of techno-politics, we argue that it is neither sufficient to treat sciences and technologies as external to "social" relations, nor as dominating human behavior and determining political outcomes. We propose rather to open up a middle zone in order to study the intersection of science and technology with international and global affairs. Conceptually, the notion of techno-politics involves two broad sets of approaches: interaction and co-production. This introductory chapter presents the chapters of the volume as examples of how the global politics of science and technology might be studied. As a toolbox of methodological insights, the contributions also point towards pathways for future research that enhances the global politics of science and technology as subfield of IR.

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The growing preeminence of science and technology in today's world no longer fits into most existing analytical frameworks. International security, statehood, warfare, as well as diplomacy, power, and global governance are strongly interwoven with and embedded in material elements, technical instruments, and scientific practices. Yet the discipline of International Relations (IR) as a whole tends to conceptualize the subject matter as exogenous to global politics. Although various studies exist and increasing numbers of IR scholars focus their research on science and technologies, the respective subfield as such has remained unrecognized. The authors of this double volume are taking seriously how sciences and technologies lead to transformations or changes that affect every subject matter of IR in a non-trivial way. Against this backdrop, our introduction to companion volume *The Global Politics of Science and Technology Vol. I* proposes the notion of "techno-politics" as an umbrella term (see Mayer et al. 2014). "Techno-politics" implies an understanding of science and technologies beyond the framework of social constructivism on the one hand, and technological determinism on the other. Neither are technologies simply byproducts or external to "social" relations, nor do sterile technologies merely determine social behavior and political outcomes. Instead, the global politics of science and technology should be placed in a conceptual zone that enhances awareness of the complexity, contingency, hybridity, and dynamism present in issue areas, research subjects, and empirical puzzles that are embedded in it (see Mitchell 2002; Hecht 1998; Fritsch 2011).

Construing a conceptual space around the notion of techno-politics supports the development of the subfield of global science and technology in four crucial ways: It connects existing IR scholarship within a specific academic context; it encourages the development of innovative research methods, analytical concepts and theoretical frameworks; it allows for different metatheoretical commitments[1]; and it functions as a boundary concept that brings IR into a productive conversation with neighboring disciplines engaged with science and technology. Widening this conceptual middle zone by means of integrating existing IR approaches and non-IR research might represent the best way to advance theoretical discourse and innovative empirical research. The study of the global politics of science and technology also sheds fresh light on traditional puzzles within IR. The subfield, in sum, contributes to broader reflections of ontology and methodology, which structure current debates in IR.

This volume advances two ontologically distinct sets of approaches based on the contributions of each chapter. The first set emphasizes *interactions* and keeps a clear distinction between the sphere of "international/global politics" and the sphere of "technology/science". It is structured around the question: *how are preexisting entities, processes, practices, and actors affected and tranformed by sciences and technologies? And how do they respond and adapt?* The second set of approaches focuses on the *productive capacity* of sciences and technologies. In this

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[1] For instance, different studies of the global techno-politics may well employ Patrick Jackson's four methodological positions (2011).

case, elements and processes of "international/global politics" are seen as inevitably intermingled and jointly produced with "technology/science". The main research question arising is: in which ways are sciences, technologies, and global affairs co-constitutive and emerge together? This simplified twofold structure reflects recent developments of the subfield. It reinforces links and systematizes comparisons and helps to further the debate about the general theoretical and empirical issues involved. In sum, the contributions of this volume exemplify ways in which the notion of techno-politics can function as an umbrella for various IR approaches.

This introduction briefly elaborates two forms of techno-politics that structure the entire book: *interaction* and *co-production*. It goes on to summarize the individual contributions of the volume, yet clusters them along an alternative logic, including *constructivist studies of technology, assemblage theories, critical and subaltern approaches, approaches to technology-based power*, and conceptualizations of techno-politics that dialogue with *International Political Economy*. In addition to the distinction between interaction and co-production, we thereby return to a conceptual debate about techno-political approaches that has been sketched out in the Volume I. Thus, this introduction not only offers specific perspectives and detailed empirical cases, but also indicates an open-ended conceptual and methodical toolbox that can be applied elsewhere to support future research work. In doing so, this introduction encourages methodological reflections and points out potential future research directions within this subfield.

1   Techno-Politics as Interaction or Co-production

Treating the international or global context of relations between politics, sciences and technology in their own right requires novel theoretical frameworks. As IR has not granted much conceptual space to scientific practices, technical systems, and technological infrastructures and artifacts, the challenge is formidable. It immediately connects to defining debates within the discipline. The studied cases of global science and technology thus also inform theoretical, normative, and methodical developments of IR theory. However, the challenge of such a conceptual zone is that it does "too easily become vague and insubstantial", as Geoffrey L Herrera states. "Placing oneself there should be done with care." (2003: 576). The main difficulty for the study of science and technology is that, at first glance, no "middle ground" exists between technological determinism and social constructivism. The conceptual place of techno-politics in IR does not simply resemble a convergence or complementarities of both, because blending two ontologically exclusive domains of reality is tantamount to conceptual self-contradiction (see Law 2004; Latour 2005). Two ideal-types or social/material dichotomies cannot overlap. Meshing together two similarly inadequate notions—a purely social and a purely technical world—does not produce viable analytical positions.

Table 1 Situating the conceptual middle ground of techno-politics

Conceptual frameworks	Main ontological domain	Mode of explanation	Carriers of agency
Social constructivism	Ideational factors	Intersubjective meaning invested into materials/technology is a matter of interpretation	Social actors, speech, texts, intersubjective practices
Technological determinism	Material factors	Material determination of social formations	Material/ technical systems and structures
Institutional externalism	Rational interactions	Institutional constraints/ conditions and patterns of calculation	Social actors, strategic practices
Techno-politics	Symmetrical treatment of ideational and material factors, hybridization, and post-dualism	Interaction/co-production creates/changes political order/ collectives	Collectives, assemblages, networks, mediating coalitions

However, if one understands techno-politics instead in pragmatic terms–that is, as different real-types of research designs and analytical frameworks–then there is a viable "middle zone". Table 1 illustrates the underlying ideas by comparing the framework techno-politics with technological determinism, social constructivism and institutional externalism (see Mayer et al. 2014). Crucially, a balanced or symmetrical treatment of material and social factors is assumed, while the modes of explanation and location of agency include substantial conceptualizations of technologies and sciences. It is in this sense that the notion of techno-politics directly speaks to the issue of rebalancing ideational and material factors in ontological frameworks (see Wight 2006; Deudney 2007). It implies, however, a fusion or an intimate interconnection and entanglement of realms that IR scholars usually have kept at great distance: the "material" vs. the "political" or the "technical" vs. the "social".

Furthermore, we suggest distinguishing between interactional and co-productive approaches. The elaboration of these varieties, by drawing on Sheila Jasanoff's work (2004: 19–22), helps to carve out a conceptual zone conducive to the study of global techno-politics. The interactional approach explores the interactions, boundary conflicts and entanglements among prior fixed entities, groups or processes such as social practices and technological artifacts. The co-productive approach sheds light on the emergence, co-production and stabilization of new things, groups, or practices such as scientific fields, objects, or technological systems. Accordingly, IR approaches can be divided into two groups.

One group, the interactional, deals with the question of how established practices or principles such as sovereignty, state authority or foreign policy are challenged by technological changes or scientific knowledge (Skolnikoff 1994; Litfin 1999). This literature comprises the examination of the consequences of the digital revolution

and information technologies for the regulatory capacity, sovereignty, and legitimacy of nation states.[2] A second major research focus is the impact of the evolving data networks, cyber weapons, and cyber space in general on "national security".[3] A related set of questions concerns the changing conduct of war affected by digital technologies in particular.[4] And also, for instance, how the use of drones impacts the ideas of "just war" (Brunstetter and Braun 2011). In addition, various authors study the responses of international institutions, norms and networks of global governance to the information age.[5] In general, the 2013 issue of the *International Studies Review* (Simmons 2013) documents increasing scholarly interest in information technologies.

Other scholars aim at reframing the concept of "power" to accommodate to the information age (Keohane and Nye 1998; Nye 2004; Mayer 2012; Singh 2013). Duvall and Havercroft (2008), for example, show how imperial sovereignty is newly framed with reference to space-based weapons. At the same time, the internet is seen as instrumental for empowering political transformation and, possibly, democratization processes. Social media have become the crystallization point for both hopes about the influence of "technologies of liberty" and fears of tools of suppression, control, and censorship. Many authoritarian states, meanwhile, have adopted highly sophisticated approaches to cyberspace that employ social networks for selective censoring and surveillance at the same time.[6] Analyzing the interplay between the "technical" and "social", the authors focus on interactions or mutual influence of pre-given concepts such as "the state", "power capacities", "society" or "national security" on the one hand, and certain technologies on the other. Their interactive puzzles put diverging emphasis on the respective sides of the equation.

The second group, co-production, starts from the idea that "the realities of human experience emerge as the joint achievements of scientific, technical and social enterprise" (Jasanoff 2004: 17). Accounting for the emergence of new structures, actors, practices, and identities, it also zooms in at the politics and sites of contestation, resistance and negotiation (Luke 1994; Whatmore 2009; Flyverbom 2011). Sheila Jasanoff's exploration of the "biotechnological empire", Ruth Oldenziel's (2011) study of the critical role of small Islands for the global extension of US military technological networks, and Karen T. Litfin's analysis of space technologies are suggestive: Litfin shows how satellites, as a technology of surveillance, have socialized a global gaze that made possible arms control both

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[2] Castells (2011), Mowlana (1997), Drezner and Farrell (2004), Eriksson and Giacomello (2009), Mueller (2010).

[3] For example, Eriksson and Giacomello (2006), Kremer and Müller (2013) see Deibert and Rohozinski (2010).

[4] See Bousquet (2009), Halpin et al. (2006), Edwards (1996), Manjikian (2010), Deibert et al. (2012).

[5] Warkentin and Mingst (2000), Deibert and Crete-Nishihata (2013), Mueller et al. (2013), Costigan and Perry (2012).

[6] See e.g. Boas (2004), Mueller and Chango (2008), Diamond (2010), Anduiza et al. (2012), Hussain and Howard (2013), Deibert et al. (2010).

technically and psychologically. This military-dominated technology, at the same time, has enabled a plethora of non-state actors who utilize images or real-time footage in order to reinforce environmental protection or monitor human rights (Litfin 1999, 2002). Litfin retains a state focus, whereas Jasanoff is unearthing a vast structure that reaches across national boundaries that tie together human bodies, metropolitan lifestyles, peripheral agricultural practices, national security policies, high-tech science, and profit strategies of large multinationals (Jasanoff 2005a). Similarly, Barry (2001) demonstrates that a technological fundament, although getting almost no attention from analysts of the European Union, is particularly critical for the success and trajectory of European integration (see also Schipper and Schot 2011). As exemplified by Laura DeNardis' (2014) analysis of the Internet, these approaches render visible previously hidden infrastructures, networks, and interwoven power relationships.

The connection between nuclear weapons and weather monitoring, in the way it illustrates the contingency of processes of techno-political emergence, figures as a major example of co-production. "The United States' foreign policy of containment conceptualized the cold war as a global struggle, reading all conflicts everywhere in the world as part of the contest for military and ideological advantage (. . .) Military technological change also increased the superpowers' appetites for global weather data and forecasts. (. . .) Tactical nuclear strategy depended on knowing the likely path of fallout clouds and the distances they might travel on the wind." (Edwards 2006: 242–243) Paradoxically, rather than deepening international conflict lines, "geostrategy and technological change", as Paul N. Edwards lucidly details, "aligned military interests with the informational globalism of scientists" (2006: 243). The exchange of monitoring weather data was nearly uninterrupted during the Cold War and collaborative efforts to simulate weather and climate eventually transformed the scientific understanding of the earth (Miller 2004).

The enormous influence of the scientific ensembles—consisting of data collection technologies, computer models and shared expertise, international research bodies—is probably best exemplified by the IPCC. Its ability to assert global policy shifts is not only indicative for the removal of power from states to international scientific organizations (cf. Edwards 2006: 250), but also necessitates a sophisticated articulation of the agency-structure problem in IR. The co-productive set of approaches ties into the growing concern with complexity and hybridity of agential forces within IR and global studies (see Glaser 2003; Youngs 1999; Townes 2012). The interweaving of technology and social practices creates a hybrid world in which the separation in human and non-human no longer makes sense. This is most discernible in the military sphere. Technological innovations in warfare have produced a cyborg-world: semi-autonomous machines and human-machine combinations are mutually connected on the battlefields and with command centers back in military headquarters. As such, the rise of network technologies and virtual realities has brought about profound and unforeseen change and feedback processes in surveillance, warfare, and power projection. In this context, war and peace, the

domestic and the foreign, humans and non-humans are becoming increasingly merged and indistinguishable, thereby challenging the common dichotomist assumption of the domestic-foreign divide constitutive to many IR theories.[7]

2 A Toolbox of Perspectives, Cases, and Methods

While the notions of interaction and co-production structure the main sections of the book, individual contributions illustrate ways in which sciences and technologies can be studied from an IR viewpoint. So, as the following chapter-summaries provide an overview about cases and perspectives, they can also serve as an alternative reader's guide. In other words, the chapters are reviewed in accordance with theory-driven groupings that relate to the open-ended set of approaches in Mayer, Carpes, and Knoblich (2014: Vol I). Constituting a methodical collection that exemplifies how empirical materials can be connected to theories, conceptual frameworks, and research puzzles, the approaches include (1) constructivist studies technology, (2) assemblage theories, (3) critical and subaltern approaches, (4) technological power, and (5) international techno-political economy. It is worth to notice that these groupings do not entail mutually exclusive analytical frameworks. As some of the chapters might be placed in more than one group, the toolbox emerging from this exercise consists of different, yet complimentary, sets of approaches that display general applicability beyond the presented empirical cases and puzzles.

While *constructivist studies of technology* challenge the instrumentalist idea that social actors can simply attach "meaning" to technological artifacts, they do not see scientific practices, epistemic communities and technical designs as objective and neutral phenomena. Instead, the latter evolve always densely interwoven with the societal and political fabric (Litfin 1994; Adler and Berstein 2005). The task is thus to explore ways in which "objective knowledge" and technical standards are enlaced in cultural traditions, ideological views and partial products of political struggles (see MacKenzie 1993; Bijker 1997; for a microsociological perspective see Knorr Cetina and Bruegger 2002). Looking at how Austrian science, technology and innovation (STI) policy-makers and related stakeholders envision and enact a close relationship between China and Austria in the field of green technologies, Ruth Müller and Nina Witjes address intersections of Science and Technology Studies (STS) and International Relations Theories. Analytically, they draw on the concept of 'sociotechnical imaginaries' (Jasanoff and Kim 2009) that stress the entanglement of visions of social order and technological development with the practical making of science and technology policy. Müller and Witjes combine the notion of sociotechnical imaginaries with Maarten Hajer's (1995) approach to argumentative discourse analysis and, particularly, with his work on

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[7] Der Derian (2009), Singer (2009), Stroeken (2013), Wall (2011).

discourse coalitions and the institutionalization of discourse. Based on interviews, participant observation and document analysis, they show how Austrian STI actors connect their national positioning activities to the recent focus on sustainability. Their chapter illustrates the interplay of meaning, representation, and emerging technical practices enmeshed in cultural traditions. They trace how these actors attempt to find common ground for relating to China by drawing on a narrative about Austrian technopolitical history and culture that casts the country as a pioneer of environmental awareness and green technologies. They understand and analyze this process as part of a broader Austrian sociotechnical imaginary in the making that constitutes a situated response to an increasingly globalized STI system.

A constructivist perspective on technopolitics can also provide a critical lens to understand bilateral great powers relations, particularly in turbulent environments and under asymmetric conditions. Richard P. Suttmeier and Denis Fred Simon examine the role of science and technology in the development of US-China Relations as a useful tool of diplomacy. They highlight how changing asymmetries of scientific and technological capabilities alter the ways in which the two countries interact. The authors point to the significant role of ethnic Chinese scientists and engineers in the United States for the establishment of a basis for collaboration. But China's growing capabilities in science and technology as well as tectonic change in international political, economic and security environments have been complicating this tool of diplomacy. While the imperatives for sustainable cooperative science and technology relationships are stronger than ever, both sides exhibit notable institutional deficiencies in governance mechanisms for realizing mutual interests. What Suttmeier and Simon thus show is how much science and technology collaboration is influenced by non-scientific factors, including ethnical networks, national identity and the general public atmosphere.

Similarly, Olof Hallonsten shows how far politics affect the genesis and development of European big science collaboration. The accounts of six cases of European big science projects illustrate that political incoherence, discontinuity and a certain degree of arbitrariness delicately impacted each of them in a different way. European collaboration in big science is built on ad hoc solutions and misses a coherent political framework and common regulatory standards. In comparison to the United States, where big science facilities are almost exclusively operating within the National Laboratories system, the lack of coherence in European collaboration made these projects prone to reflecting general trends in European politics at the times of their realization. They were therefore vulnerable to uncertainties indicated by repeated ruptures and break-offs in international science collaboration.

Johan Eriksson and Giampiero Giacomello analyze the threats embedded in the rapid expansion and increasing accessibility to the Internet. As they argue, the Internet has long become a topic of political (and military) interest, shifting from the technical managerial realm to the attention of foreign and security policy (cf. Dunn Cavelty 2013). The analysis of the cyberspace is challenging to the extent that not only the state, but also non-state actors play an important role in securing this realm. Furthermore, it questions the traditional threat perception that would

place the enemy in the "real" world. The study of cyberspace and cybersecurity subvert these logics, therefore calling for new analytical tools. To address the topic, the authors combine constructivist theory with content analysis—that is quantitative method focused on key words searching. They argue, on the one hand, that content analysis is a pertinent instrument for the study and practices of cybersecurity, considering that a significant amount of information on the Web is text. On the other hand, constructivism is particularly useful for uncovering the text-based meanings, identities, symbols and ideas that largely constitute the "virtual" world. Together, theory and a set of methods allow for an assessment of how reality is perceived and discourses (of cybersecurity) are built within cyberspace.

Assemblage theories emphasize complexity and make global actor-networks a prime object of study (Acuto and Curtis 2014). The starting point here is the idea that "politics" themselves emerge from an empirical density in which "social" and "material" factors cannot easily and a priori be distinguished (Latour 2005). This insight is exemplified by the extent to which inter-state cooperation, scientific networks, or the spread of technologies is dependent upon and embedded in large-scale infrastructures. The latter facilitate production, trade, finance, communication, surveillance, and defense systems which are far more complex, multi-sited, and interconnected than any state-centric framework of social collective action can cope with.

In this vein, Alejandra Kern and Hernán Thomas analyze international technological cooperation processes between developing and developed countries. Similar to Suttmeier's and Simon's study, an asymmetric relationship is explored. They present an analytical framework based on two notions: First, they refer to Robert Cox's (1987) reflexive approach claiming that production and dissemination of technology is a result of a social process involving power relations and constituting core-periphery divides. Second, they define cooperation processes as socio-technical trajectories drawing on Michel Callon's (1992) definition of "techno-economic networks" (TEN). Adding a political pole (P) at the center of this network, TPEN frames their analysis of Argentine-German cooperation in Informationa and communication technologies. Thereby, they connect approaches from IPE and Social Studies of Science and Technology in order to build up an analytical framework that allows for the analysis of varied TPEN configurations and the path of cooperation processes. The case of German-Argentine cooperation in ICTs illuminates how the structure of international order influenced the way ICTs were politicized in the 1990s—differently in both countries. The case furthermore illustrates that the evolution and the results of scientific and technological cooperation is largely explained by the ways research teams interact.

Drawing on Actor-network theory (ANT) and STS, Annegrete Juul Nielsen and Henriette Langstrup focus on the role and effects of technology in global encounters. The chapter evolves in a case study of the Danish-Indonesian partnership to implement Danish software for diabetes management in Indonesian primary care. It is structured around fieldwork done in Denmark and Jakarta, Indonesia, comprising interviews and analysis of primary documents. Methodologically, they propose an ethnographic study of health technologies—more specifically, global diabetes

encounters as an empirical phenomenon. By "encounter" they mean concrete and potentially frictional contacts between specific human and non-human or technological entities meeting and creating relations that transgress national boundaries. The authors claim to identify a process of co-constitution between global encounters and technology. Such a process, they argue, also produces frictions that have to be observed for their insights into the conditions for the intersection of Global Health and International Relations.

Peer Schouten explores technological infrastructures in postcolonial Africa. Combining detailed fieldwork, interviews, and multi-site case studies, the *problematique of absences*—such as roads, statistical tools, and government offices—is addressed against the background of the historical state formation of the Democratic Republic of Congo. Theoretically, this chapter points to an analytical gap emerging at the overlap of political science and science and technology studies. Where political science has been negligent at dealing with the importance of technological infrastructures for the constitution of governmental power, science and technology studies have hitherto been less attentive to situations in which such 'infrastructures of rule' are *absent*. Using the "chukudu"—an improvised wooden transport utility that allows Congolese to go about despite decrepit roads—Schouten's study shows the significance of missing infrastructures, suggesting ways in which IR could draw on insights from Michael Mann's (2008) work about technological infrastructures and statehood. Assemblage theory hence enables novel insights in the importance of technological asymmetries in global power-relations in postcolonial contexts. In terms of method, this chapter combines "thick description" with critical reflections about axiomatic notions underpinning both political theory and IR.

Critical and subaltern approaches stress the technological dimensions of core IR themes such as security, warfare, order, and anarchy that are otherwise hidden and remain unacknowledged.

Anna Agathangelou offers a triangular assessment of global politics that encompasses the IR debate on order/anarchy, and recently emerging biomedical technologies. Building upon a integrative framework of postcolonial studies and STS, she outlines the fact that the scientific and the social/political are always already inside one another and extends this premise to the analysis of the international. The article draws on life science and bio-capital, calling attention to the fact that the moral expectation for capital is shifting our understanding of healthiness and value in their relation to corporeality. In terms of tools for further analyses, one challenging lesson to be taken from Agathangelou's article is the link that she proposes between bioscience and international relations; or as she phrases it, the corporeal and the architecture of the international that can be studied through popular literature and imaginative theatre, complimentary to empirical analysis of transnational techno-economical interactions. The chapter thus offers new avenues to critically analyze and bridge the sides of an apparent divide, that is, the global commercialization of medical science, genetechnology, and the international politics (of bodies).

The chapter by Niklas Schörnig asks why military robots and drones are specifically appealing to Western democracies and where this appeal might come from vis-à-vis alternative weapon systems. When it comes to military robotics in

general, the "technological imperative" seems to be a valid and powerful explanation for the worldwide proliferation of drone technology. What is missing from a realist explanation, however, is why drones have become so popular in the first place and especially why Western democracies have been implementing and fostering their development from the very beginning. Referring to liberal theory, the text argues that unmanned military systems offer Western democracies a unique opportunity to implement what has been termed the "New Western Way of War". Instead of viewing "technology push" and "mission pull" as two contradicting explanations of technology development, Schörnig suggests that a combination of both offers a comprehensive picture. While warfare with minimized risks for soldiers and reduced civilian casualties seems to be a worthwhile goal, it demands further attention whether there are less pleasant backlashes of these technologies on democratic norms and institutions. Methodically, this implies a focus on the links between technical details, the evolution of norms, public discussion and actual practices of warfare.

A critical view might study technologies and scientific knowledge production as a *form of ideology*. For example, Susanne Peters and Peter Zittel stress the consequences of the illusive narrative of optimism—the belief in the limitless power of technology that has dominated the Western world since modernity. They use the "tight oil revolution" as a case study showing, on the one hand, that natural factors such as steep depletion rates are alarming symptoms of its lack of sustainability. On the other, they demonstrate that the emergence of this revolution is only partially linked to the "power of technology"; it is also linked to deregulation and Wall Street economics. The authors claim that there are insurmountable limits to technology's "domination of nature" and reflect how far this recognition has to be internalized into IR. They employ their example in order to demonstrate that social scientists and IR scholars in particular need to overcome the discipline's traditional inherent dichotomy between nature and society, and develop theories and concepts explaining the dynamics between energy use and political outcomes. For a peaceful transition from the fossil to the post-fossil world, they argue, we urgently need to develop models, new ideas and new comprehensive approaches integrating nature and society—and also insights from economics, geography, physics, and geology—in order to foster the feasibility of a post-carbon life style.

Jayita Sarkar's analysis of the trajectory of the Indian atomic energy program emphasizes the *irrationality* hidden behind technological ideology. Drawing on primary sources to build a historical narrative of the curiosity-indigeneity paradox, as she calls it, Sarkar analyses the 1951 Franco-Indian nuclear cooperation agreement and India's thorium research and development enterprise. She argues that such paradox is the discursive justification of expensive scientific and technological projects without any tangible impact upon national development. On the one hand, the task of national development in resource-scarce India necessitated scientific projects that made immediate contributions to the socio-economic improvement of the lives of its citizens. On the other hand, the discourse of indigeneity, by underlining the need to establish a domestic scientific knowledge base, justified curiosity-driven research only for the sake of scientific progress itself. The idea that

modern technology becomes a mere fetish speaks to earlier insights from IR how weapons are often irrationally turned into instruments national prestige.

Approaches to ***technology-based power*** raise the diversity, unintended consequences, and paradoxes of techno-political power shifts, influence and control.

With the help of proxy indicators, Katharina Below, Sarah Herweg, Ruth Knoblich, and Krystin Unverzagt show that asymmetries persist in cross-country knowledge distribution. Reframing an instrumental understanding of power with the notion of "knowledge power," they make reference to structural approaches such as the concept of structural power by Susan Strange (1988). Structural power impacts the range of choice and the opportunity to develop through network functionalities. These networks, which make up for the global knowledge structure, are assumed to provide an inert environment in which states face restraints on development and their way up to leading positions. As the asymmetric distribution of knowledge capacities derives from past differences in foundational knowledge indicators, power shifts cannot appear out of a sudden, and established powers are likely to prevail. Methodically, this chapter provides a set of indicators, elaborating on options to quantitatively measure global structures.

According to JP Singh, large-scale and dense communicative interactions among multiple actors are creating new and shared understandings in global politics that, in turn, require efforts to re-conceptualize power. The existing "instrumental" conceptions of power tend to underestimate the role of communication in these politics. Singh argues that the increasing intensity of debates on cultural identity exemplify the new meanings that arise in global politics as a result of *large-scale communicative interactions*. Thereby, national identity is not replaced but supplemented with other forms of cultural identity in a networked world. The chapter develops the concept of meta-power in order to capture the emergence of these new. Singh suggests several locations to study the involved techno-politics, ranging from national debates about identity, to the activity of international organizations, and governmental negotiations about intellectual property and the trade of art and cultural products. In addition, a sort of new cosmopolitanism that embodies meaning beyond territorially bounded social formations might emerge due to the transnational network communication practices.

From a different angle, Anna Harrington and Matthias Englert employ concepts from STS to assess the nuclear choices of non-nuclear weapon states. Drawing on the literature about nuclear (non)proliferation and on technical knowledge about uranium enrichment centrifuges, they ask how much nuclear power is enough for a country to perceive itself as safe. Their core argument is that states do proliferate when the benefits outrange the costs of going nuclear. Subsequently, they question a well-accepted discourse in IR about absolute values attributed to nuclear weapons. They argue instead that nuclear technologies are "inherently ambivalent" because different actors can attribute different meanings to them. According to the authors, the deterrence aspect of nuclear proliferation can be achieved without proliferation in itself. In this sense, they offer new lenses to assess deterrence in the case of non-nuclear weapon states: instead of real arsenals, latency—the capability to assemble nuclear weapons in a relative short period of time—can suffice to produce

the desired deterrence. The bonus of a virtual arsenal lies in not having to pay the financial and political costs of proliferation.

Infusing conceptualizations of interaction or co-production into theories of **International Techno-political Economy** leads to approaches that zoom in at the technological micro-practices and macro-processes that perform and stabilize "the world economy". This conceptual move does not only shed light on how shifting technological monopolies, such as over the collection of big data, produce new landscapes of power and influence (see Nye 2004; Andrejevic 2014). It also leads to a critical inquiry of the evolution of measurments and standards that inevitably underpin our knowledge of economic growth and development.

For instance, stressing the significance of statistics and measurement of science and technology for policymakers and vice versa, Benoît Godin and Joseph Lane illustrate how official statistics of a national scope were transferred into the international arena after World War II when science and technology indicators particularly became crucial for the comparison of European economies and the US. Organizations such as the OECD started measuring cross-country innovation performances and established a standardized set of science and technology indicators that allowed for international comparison, focusing on competitiveness. While the OECD reoriented its whole statistical program in science and technology in the 1990s in order to adapt to globalization processes, the established indicators did not undergo a further restructuring, but were just re-interpreted. The authors expose how far indicators of science, technology and innovation are still driven by competition categories and do not measure what policymakers claim technological and scientific development should serve. Accordingly, methodologies and outputs are necessary to create new nets of social and economic wealth. One example could be the indicators measuring innovation in terms of commercial exploitation and industrial production. Taking into account that statistics today remain primarily national in scope, the authors question whether one could really talk about an international dimension to science and technology for consideration by governmental policymaking bodies—as there is for climate change.

Sean Costigan and ERICA Dingman ask how the immense amount of scientific data that is produced worldwide could be used to improve economic and environmental policy-making on a regional level. They raise the questions of how to make sense of it, and also how to have access to it, considering that an enormous amount of valuable data is not open for free access. Offering a policy-oriented study, the authors draw on the case of the Arctic, an emerging region, to debate the role of technology, environment, energy and access to knowledge in the context of the regionalization of policy-making. They call for improving "access to and share of raw data as well as access to method used to produce the data". They outline that the field of climate policy evidences a ineffective fragmentation of data and the existence of a divide between production of knowledge and access to this knowledge for the sake of policy-making and spreading of information. They suggest that the lack of a "neutral space" to collect, share and communicate needs to be overcome. Given the growing importance of big data, this chapter stresses the technopolitical imperative of enabling efficient policy-making and, thus, to

improve the results for involved participants in a far-flung region such as the High North that is especially characterized by a volatile environmental situation.

3   Conclusion

The subfield of global politics of science and technology entails a great variety of approaches. This introduction has focused on two different "techno-political" perspectives, interaction and co-production, indicating that they offer a productive theoretical starting point for research. These perspectives open up novel analytical understandings of classical problems of international politics. In particular, the summarized examples illustrate how scientific practices and technologies of all kinds are both interacting with and constitutive to various levels, units, actors, structures, and spatial dimensions. The "state", the "region", the "international", and the "transnational" are maintained through and changed by technologies. Hence, detailed empirical accounts add a diversity of actors, relationships, and collectives alongside classically tailored case studies and framings of analysis. At the moment, the criteria for knowledge production in this subfield remain open-ended. On the most fundamental level, explorative research in this field is driven by the idea that sciences and technologies cannot be treated merely as by-products or external to "actual" politics (see Table 1). Their limits are not easily definable by means of deduction or a priori categorical delimitation. Instead the characteristic quality of sciences and technologies lies in exploring and reconstructing globally stretching interlinkages and connectivities (see Adger et al. 2008; Linklater 2009; Urry 2003). In doing so, authors emphasize techno-political processes of interaction and co-production, bringing into the limelight the multidimensional and extensive, yet often highly fragile, role of material agency to which societal patterns and meaning are tied (Jasanoff 2004, 2005b; Barry 2013; Connolly 2013). The latter constitutes a deeply political issue that remains usually hidden by conceptual and academic demarcations and compartmentalization which unfortunately are still constitutive for most social theories and IR approaches. Finally, it is not by coincidence that the chapters construct solid bridges to several neighboring disciplines, as serious interdisciplinary engagement and mutual learning are crucial for the methodical and theoretical innovations driving this research field.

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