The Global Politics of Science and Technology: An Introduction

Maximilian Mayer, Mariana Carpes, and Ruth Knoblich

Abstract The reality of international politics has rapidly grown in complexity. This complexity has been pressuring the discipline of International Relations (IR) to engage with new phenomena, concerns, and issue areas, and to translate them into innovative theorizations. Science and technology is one of these issues. Contemporary human life is tied to and thoroughly permeated by artifacts, technical systems and infrastructures, making it hard to imagine any international or global issue that does not have technological or scientific aspects. However, this condition remains fundamentally challenging for many approaches within IR, in which instead science and technology have been largely treated as exogenous. Although an increasing number of IR scholars is exploring the roles scientific practices and technological systems play in international affairs and global politics, the subject matter deserves much more systematic scrutiny. The following chapter articulates the conceptual, intellectual and academic contexts of this two-volume collection on the *Global Politics of Science and Technology*. After pointing out general normative challenges and briefly problematizing global technological transformations, we recapitulate the evolving IR scholarship on the topic. We argue that, although most IR theories do not grant science and technology a genuine conceptual place, there is enough research to document and reconstruct the breadth and depth of the vivid, yet unrecognized subfield of IR. While the further development of this subfield would greatly benefit from interdisciplinary conversations, we propose the notion of techno-politics to

M. Mayer (✉)
CGS, University of Bonn, Bonn, Germany
e-mail: maximilian.mayer@uni-bonn.de

M. Carpes
GIGA, Hamburg, Germany
e-mail: mariana.carpes@giga-hamburg.de

R. Knoblich
IEE, Ruhr-University Bochum, Bochum, Germany

IPWS, University of Bonn, Bonn, Germany
e-mail: ruth.knoblich@uni-bonn.de

M. Mayer et al. (eds.), *The Global Politics of Science and Technology - Vol. 1*,
Global Power Shift, DOI 10.1007/978-3-642-55007-2_1,

indicate how the discipline might rearticulate existing analytical frameworks, establish innovative conceptualizations, and advance new concerns for research.

Keywords Technology • Science • IR theory • Techno-politics • Global transformations • Technological determinism • Interdisciplinarity

1 Introduction

The reality of international affairs has rapidly grown in complexity, pressuring the discipline of International Relations (IR) to engage with new phenomena. IR scholarship thus has to address concerns and issue areas by translating them into innovative theorizing. Science and technology is the most prominent among these—it is hard to imagine any international or global issue that does not entail technological or scientific aspects. International security, statehood, global governance as well as warfare and foreign policy are thoroughly permeated by and embedded in material artifacts, technical systems and infrastructures, and scientific practices. As topic, science and technology attracts significant attention within IR; security studies are perhaps the most notable case, treating science and technology as key strategic tools in the Cold War. However, for many approaches within IR the analysis of science and technology remains fundamentally challenging. They have been largely treated as exogenous to theoretical schools and the field. Thus, while an increasing number of IR scholars are looking at the politics of science and technology, the subject matter needs to be scrutinized much more systematically. The discipline still needs to build up internal logics capable of integrally capturing the diverse meanings and dynamics of science and technologies. On the other hand, the study of (global) science and technology has become a diversified multidisciplinary effort. While a large research area exists that partly overlaps with issues in IR and often challenges central premises of IR, it lacks substantial contributions by, and sustained connections to, IR scholarship.

Having this in mind, the present two volumes explore the politics of science and technology from a variety of perspectives ranging from classic themes such as nuclear weapons to recent debates about nanotechnology, drones, peak oil, cyberspace, supercomputers and biomedical technologies. The collection pursues two central aims. First, it documents the breadth and depth of research about the *global politics of science and technology*. We argue that it already constitutes a vivid, yet largely unrecognized and still underexplored, subfield of IR. Second, these volumes present detailed empirical studies and diverse efforts of theory building by senior and junior researchers that reinforce a commitment to interdisciplinary dialogues with those research areas in which science and technology have traditionally played a central role. The first volume provides a state-of-the-art compilation of respective debates and research in IR. In addition, it introduces alternative and/or complementary contributions from geographers, theorists of science and technology, historians, and economists on the subject matter. Thereby a space for mutual

learning is carved out, contributing to a better understanding of the canvass of the global politics of science and technology. The second volume features various case studies and perspectives. Based on new concepts and methods, the authors analyze how and to what extent different technical networks, artifacts, and scientific practices shape, perform, and transform global politics today. We invited authors and theorists from different theoretical perspectives and disciplinary backgrounds to articulate core issues at stake. This way we hope to clarify the historical, disciplinary and conceptual background of the global politics of science and technology.

To begin with, this introductory chapter highlights that the meanings and purposes of science and technology are deeply contested in today's social sciences. Two conflicting perspectives on technology, an optimistic and a skeptical view, raise difficult theoretical and normative challenges for IR. Historically, analyses in the discipline studied global technological transformations and military revolutions in modern world politics. In particular, nuclear strategies were a core issue of the first great wave of IR scholarship that, emerging after World War II, fully established the discipline as such. The next wave, beginning in the 1970s, shifted the focus to state-market relations, and then increasingly to global interconnectedness. Nevertheless, the overall attention of the discipline to technology and science remained remarkably narrow, particularly with regard to theorizing. While this gap would require a more comprehensive discussion, in the present chapter we can only sketch it out, by outlining clusters of interrelated intellectual contextual factors. Most importantly among them are the dominance of instrumentalist understandings of the material world and the ideational bias of leading IR schools. In part, this might explain why IR—unlike many other social science disciplines—did not develop a distinct subfield around technology and science. Finally, by employing the notion of techno-politics we explore how IR might construe a conceptual place for science and technology by reformulating existing puzzles, opening up space for new topics and synergize existing research.

2 Two Tales of Technology

Studies that focus on science and technology inescapably become embroiled in normative questions concerning meaning, purposes and consequences. IR is no exception. For the present discussion, we organize these normative issues at play in the broader social science debate around science and technology into two conflicting narratives: the first could be called a *tale of hope*. It conveys the optimist idea that advances in technology and science tend to make society better. The second is a *tale of pessimism,* assuming that new technologies and scientific advances have potentially negative or even disastrous consequences. Subsequently situating existing work in IR within these conflicting cultural narratives reveals that the subject matter hardly allows for a neutral analytical position. All politics are entwined with technologies and sciences in a great variety of ways going well beyond the conceptual apparatus of IR.

The core assumption of the first narrative is that subsequent stages of technological developments lead to significant improvements of economic progress and human conditions. It is assumed that a combination of science and technology offers better solutions to critical global challenges such as security, public health, energy, food and water supply, poverty, and climate stability. The overarching trends towards more efficiency, smartness, and artificial intelligence are understood as not only reshaping and redesigning but actually improving urban planning, reproduction, advertisement, and business models (e.g. Kurzweil 2006). From a different angle, proponents of this narrative endorse the development of smart technologies in order to mitigate the assumed limits of economic growth. Hyper-efficiency is presumed as one of the preeminent (technology-based) building blocks for fostering wealth and a decent life for nine billion people within our "planetary boundaries" (see Byrne and Glover 2005; Pielke et al. 2008). International institutions such as the World Bank and different UN initiatives call for closer international cooperation in scientific research and technological development. They argue in favor of global developmental research that makes use of open data, open access to research pools, and collaborative knowledge production. In addition, through the systematic use of "big data", the UN pushes the realization of the Millennium Development Goals and the Post-2015 Development Agenda (United Nations 2012, 2013). Furthermore, experts hope that the rapidly growing relevance of Internet-based telecommunications would render digital infrastructures and applications instrumental to modernizing agriculture (Juma 2010).

Of course, techno-optimism equally applies to the military realm, as illustrated by Anders F. Rasmussen's recent appraisal of advanced missile defense capabilities of NATO:

> To link all of these national assets together, NATO has developed, and is expanding, a technologically advanced command-and-control system, based at Ramstein Air Base in Germany. The system already can connect satellites, radars, and interceptors to defend against missile attacks, and that capability will grow more complex and agile in the years ahead. This makes NATO unique: it is the only multilateral organization that can combine the most complex systems from the world's most capable countries to create an effective whole (Rasmussen 2014).

Similarly, it is asserted that the employment of autonomous and unmanned weapon systems makes warfare more precise, allegedly less inhuman, and thus an ethical imperative (Arkin 2010; see Kaag and Kaufman 2009). The idea of the "technological fix", to put it differently, dominates decision-makers from Beijing to Kinshasa and from Washington to Brussels. In short, the optimistic tale of technology is driven by unmitigated ambitions and high expectations about continuous improvements. However, the assumption that technology and science primarily are instruments of progress is contested.

In opposition to the first narrative, many observers express skeptical or at times pessimistic views. Proponents of this view consider a fetish of modernization the belief in unending opportunities and inevitable triumph of emerging technologies and scientific knowledge. In particular, some see technological determinism as a powerful modern ideology shared across diverging cultural and historical experiences and within different political and economic systems (Adas 1989; Smith and

Marx 1994). Hence, cautious voices call for self-imposed limits in order to avoid direct links between scientific progress and weaponization, warning at the same time against the increasing militarization of academic research (Price 2011). The inherent *risks* of pollution and ultimately annihilation, paradoxically resulting from technological progress, and the objective status of related scientific knowledge itself became subject of public concerns and contestation in the late 1960s (Lear 1993; Jasanoff 1990; Nelkin 1992). According to sociologists, our societies have already reached the state of "reflexive modernity" in which unintended consequences of technologies are taken seriously in, but continue to outpace mainstream central planning and political discourse (Beck 1992; Beck et al. 1994). On the sidelines, only a few marginal voices keep insisting on "simplification", de-growth, and "appropriate technologies".[1]

From a skeptical angle, "technological progress" is thus seen as the last remaining great myth of the postmodern age. It seems resistant to an unending series of catastrophes, accidents and pending risks of annihilation related to modern weapon systems, fragile infrastructures or the proliferation of toxic particles and artifacts (see Virilio 2010). Early IR scholarship on deterrence and nonproliferation of nuclear weapons belongs, in a sense, to the pessimistic perspective as it was occupied with the nightmare of managing the "absolute weapon" in the context of strategic and ideological rivalry. However, Eric Schlosser's (2013) frightening account of the number of nuclear accidents indicates that nuclear arsenals are generative of existential security threats in addition to their strategic dimensions, on which IR puts its main emphasis (e.g. Mueller 1988). After 1945, more than 1,000 accidents have occurred in the United States alone. The consequences of nuclear catastrophes such as in Ozyorsk, Chernobyl, and most recently Fukushima are likely to last for at least ten thousands of years. They are truly global in their reach and impact—as holds true for the immense waste lands created by mining radioactive ores, testing weapons, and dumping nuclear materials (Makhijani et al. 2000; Hecht 2012).

It is in this sense that the second tale entails a dystopian register. It pictures individual and collective life emerging through oppressive technical ensembles, which have often deteriorating consequences for individual life and social coherence. From a critical view, scientific and technological progress and specific technologies as such are never neutral. They can even express irrational or inhuman ambitions (Feenberg 1999). Besides the industrially planned and organized area bombing campaigns during and after World War II, there is perhaps no better illustration of the dire consequences of technological capabilities than the crucial, yet often overseen, role of scientists and technologies in the realization of the Holocaust (Thad Allan 2001; Bauman 2013). Moreover, the extent to which modern sciences and technologies were implicated in colonial domination, racism,

[1] Precursors include Ralph Waldo Emerson, Ivan Illich's work on energy, Ernst Friedrich Schumacher's notion of "appropriate technology" and Masanobu Fukuoka's insights about farming.

and exploitative suppression, both practically and as a "white mythology",[2] has remained largely under-scrutinized in social sciences (Adas 1997; Endres 2009).

This pessimistic understanding usually refers to—correctly or incorrectly—the reasoning of influential thinkers such as Henry D. Thoreau, Max Weber, Martin Heidegger, Max Horkheimer, Lewis Mumford, Walter Benjamin, Jacques Ellul, Norbert Elias or Michel Foucault (Berman 1983; Mitcham 1994; Matthewman 2011). When the experience of the First World War shattered Europe's claim to civilizational superiority, non-Western thinkers including Mahatma Ghandi and Rabindranath Tagore also scrutinized the non-civilized and horrible side of Europe's technological advances (Mishra 2012). Public figures such as Albert Einstein and Albert Schweitzer adopted their "peripheral" outlook; a view that was in fact a Southern precursor of the anti-nuclear movement in the 1960s and 1970s. The most recent example for profound techno-pessimism is the deteriorating perception of the World Wide Web. Many are coming to see digital networks turning from an erstwhile tool of liberty, consumerism, and cultural exchange into an intrusive instrument of state oppression, censorship, and espionage inescapably bound to further erode personnel freedom and privacy (Deibert et al. 2010; MacKinnon 2013).

Of course, these two tales are over-simplifications of a much more differentiated concert of responses to the technological condition of humanity. Nevertheless, they are useful insofar as they indicate normative and conceptual challenges with which the discipline of IR has to reckon. Firstly, although early realist thinkers including Hans J. Morgenthau and John Herz occupied a fundamentally critical position towards modern technologies (Scheuerman 2009; van Munster and Sylvest 2014) the optimistic tale of technology arguably functions as the implicit default position within most IR literature. As the discipline increasingly reflects upon the significance of technology and science, it has to engage with the difficulty of retaining a seemingly "neutral" analytical position (see Richards and Ashmore 1996; Jasanoff 2003). Authors in science and technology studies (STS) as well as in feminist and postcolonial studies stress that technologies inherently *have politics*—albeit in ambivalent ways. Consequently, they reject instrumental understandings. As science and technology are deeply implicated in the fabric of life and society, they cannot be objectified, that is, treated purely as means of economic or military might.

These insights help IR approaches to cultivate a dose of sensitivity for the intimate link between normative and methodological issues.[3] Secondly, both tales—especially in their stronger deterministic versions—tend to deemphasize political deliberations and power struggles that evolve and are weaved *through* technologies and sciences. As Evgeny Morozov (2014) argues with respect to communication gadgets and networks "there are different ways to wire the world": The inherent danger of "Internet-centrism" is that our "infrastructural imagination gets atrophied to a point where we can no longer imagine how to

[2] Dinerstein (2006: 578) labels this discursive ensemble as "fusion of progress, technology, and religion" structuring Euro-American identity.

[3] See Winner (1980), Haraway (1991), Joerges (1999), Woolgar and Cooper (1999), Rose (2007).

organize our technological affairs" (see Morozov 2013). The theoretical and analytical challenges for IR, therefore, consist in neither reducing all technology to social construction, nor reducing all politics to technological determination. Additionally, a reflection on the two tales invites IR to overcome its often purely instrumental view in order to confront the hidden and often dire consequences of the pursuit of science and technologies beyond the immediate concerns of foreign policy, state power, efficient governance or national sovereignty.

3 Global Technological Transformations and the Limits of Determinism

While some narrate human history as a sequence of technological revolutions (Innis 1950; Mumford 1966; White 1966; McNeill 1982), the link between global or international transformations and technological changes became especially virulent with the onset of modernity (Harvey 1990). Yet, it remains a challenging task to analyze the nexus of technologies and changing political orders in a non-deterministic way. For example, at the peak of colonialism and imperialism, observers and colonial administrators recognized the reality of time-space compression. Technological innovations such as electronic telegraphy, new means of traffic, and other globe-spanning infrastructures rendered the geography of the globe into a single entity (Bayly 2004; Osterhammel 2009). The ability to innovate, employ, and control novel instruments of knowledge and communication also became crucial for hegemonic transition and the (de)stabilization of international dominance (Hugill 1999). Halford Mackinder famously noted that the newly materialized communication and traffic pathways constructed a "closed political system" (1904: 422). Yet, others have argued that Mackinder's claim actually had already been realized through the naval revolutions and trade networks of the fifteenth and sixteenth centuries (Cipolla 1965; Braudel 1982; Frank 1998). Technologies and scientific innovations served not only as tools for imperial projects (Headrick 1981; Zaheer 1996; Yang 2011), but also facilitated and accelerated in multiple and unforeseen ways globalization of commercial competition, statehood and modern culture (Chandler 1977; Hughes 2004).

At the turn of the twentieth century, the international political system again appeared to experience a sea change because of path-breaking information technologies. In the 1990s, theorists pinpointed the rise of an info-sphere and digitalization as redrawing fundamental parameters of society, economy, and politics (Rosenau and Singh 2002). Seen as the real engine for the latest wave of globalization, some argued that the new Information and Communication Technologies (ICTs) had given birth to a network society (Castells 1996). On the one hand, ICTs shrunk the world into a "global village" (McLuhan and Powers 1992), leading to "flattening" the international landscape of commercial competition (Friedman 2009). On the other hand, they were seen as producing a digital gap, placing those societies, firms, nations and individuals that have access to ICT networks in

an advantaged socio-economic and political position. Moreover, it has been argued that a crucial side effect of ICTs is an ongoing and profound shift of power and authority towards private entities, that is, mainly economic actors in global affairs. While earlier technological changes already had ambivalent consequences for the national sovereignty, weaving an unprecedented techno-scientific web among allies and foes alike during the Cold War (Edwards 1997; Krige et al. 2013), the rapid dynamics of innovation in ICTs arguably reinforced a divergence of market actors and states.[4] In this sense, "big data" is the latest wave of ICTs' transformative power in dividing positions: those advocating the notion of cost-effective supra-governmental sources of information are contradicted by those fearing a complete loss of democratic control over data gathering, storage and privacy (Bollier 2010; Bauman et al. 2014).

Military revolutions are perceived as the most pertinent cases of novel technologies fomenting massive global changes (Delanda 1991; Hoyt 2003). The employment of new technical devices and systems recurrently transformed warfare. Among the examples are clocks, airplanes, missiles, barbed wire, diesel engines, drones, hacking software, and so forth. At the same time, a substantial share of scientific inquiry and commercial research and development came to serve the needs and desires of national armed forces (Bousquet 2009; Der Derian 2009). Aside from their effects on battlefields, advances in weapon systems have also had far-reaching political ramifications. For instance, IR regards nuclear physics most prominently for having essentially altered statecraft and international relations forever (Jervis 1989). Bernard Brodie (1946) saw the radical impact of the "Absolute Weapon" in reversing the purpose of the military establishment from winning wars to averting them. Nuclear weapons amassed more power into the hands of national armies than ever before, while apparently ending the era of wars directly fought between great powers (van Creveld 1993; Mueller 1989). However, nuclear weapons were not simply shaping history. Numerous scholars and experts saw improvements in weapon technologies causing dangerous shifts in the defense-offense balance of power, which led to uncontrollable political and military responses during the 1950s and 1960s (Freedman 2003). But linking military revolutions to determinist understandings has its pitfalls, as Francis J. Gavin points out:

> Focusing solely or even largely on nuclear weapons to the exclusion of geopolitics, ideology, and diplomacy caricatures both the Cold War and international politics today by draining them of important political and diplomatic components. (Gavin 2012: 150–151)

Moreover, the unpredictable and non-deterministic interplay between nuclear technologies, power and security is exemplary for numerous other technological and scientific harbingers of transformation. The advent of airplanes, rocket missiles, radio, telegraph, satellites, and other revolutionary technologies turned simplifying accounts of the nexus between technology and geography (or between technology and power) ultimately obsolete. The unexpected interplay between the newly

[4] Most prominently embodied in the massive increases of product and capital flows seemingly governed by timeless and spaceless regimes that supersede and restructure the nation state matrix (Keohane and Nye 1977; Strange 1996; Ronen 2003).

constructed undersea cables, imperial competition and governance, global and local media outlets and markets during the late nineteenth century is another vivid illustration (see Potter 2007). It is exactly this intimate, yet contingent and controversial connection between politics, technologies and scientific practices that poses difficult conceptual challenges to IR. Yet, as Morgenthau (1964) has pointed out, neither domestic politics nor geopolitics and geoeconomic patterns can be properly understood if separated from matters of technology and science.

4 From States and Markets to Complex Global Interconnectedness

Aside from security studies (Buzan and Hansen 2009), researchers who inquire into the interaction of states, markets, and enterprises have taken up the issue of science and technology. This section explores the main challenges at the forefront (and across that edge) of IR theorizing on science and technology. The idea that the state should organize education and foster sciences has a long lineage. Likely it's most prominent proponent was Wilhelm von Humboldt. At the turn of the eighteenth century, he laid the intellectual groundwork for decades of institutionalization efforts, restructuring schools, universities, and academic disciplines in Prussia and eventually in many European states (Paul 2003). Indeed, at a much broader scale and with a multi-dimensional range, experimental science, engineering, and architecture became the actual core of state formation from the eighteenth to the twentieth century—a set of practices that centralized power by manufacturing the state into landscapes, cities, epistemic infrastructures, and individual subjectivities (Shapin and Schaffer 1985; Skocpol and Rueschemeyer 1996; Carroll 2006; Guldi 2012; Scott 1998). But it was the experience of two World Wars that impelled nation-states to rigorously and persistently steer and fund scientific research. Vannevar Bush's 1945 report *Science, The Endless Frontier* to the US president, firmly cemented the notion of state involvement in basic research and development. Besides colonial expansion, security threats and Cold War enmity were the original rationales for state-financed science (Wolfe 2013). Massive public investment enabled large-scale research to produce innovations such as particle accelerators, satellite systems and supercomputers. Those "big science" projects marked a new era of science and technology policy. They raised national prestige, technological expertise (see Kevles 1977) and—as in the European case—intergovernmental collaboration that affected profoundly the international landscape of technological competition. More than any previous hegemonic power, the preeminent position of the US developed in relation to its scientific and technological leadership (Paarlberg 2004; Krige 2006; Hecht 2011); to use Adas' (2006) phrase it is *Dominance by Design*.

In the early 1960s, the Organization for Economic Co-Operation and Development (OECD) emerged as the most influential international body comparing technological progress. By measuring cross-country innovation performances by R&D

investment per GDP and the quantity and quality of "knowledge workers", OECD experts enshrined the idea of the competition-state. In addition, economists, sociologists and the OECD later promoted the concept of the "knowledge economy". As technological expertise and innovation capacities became increasingly considered decisive factors for development, economic growth, and social welfare, building up a "knowledge society" through international education and professional training programs became the key objective of international organizations (Moldaschl and Stehr 2010; UNESCO 2005). Drawing on Amartya Sen's capability approach (1999), the notion of knowledge societies reinforced the vision of development concepts that view education as crucial for sustainable development. The contemporary concern with innovation and scientific ingenuity are mirrored in the growing attention that politicians, public institutions and businesses pay to the uses, effects, and regulation of emerging technologies. Regulations of intellectual property rights turned into the most prominent battleground of rivaling interests, mainly evolving around the agreement on Trade Related Aspects of Intellectual Property Rights, the World Intellectual Property Organization and the question to what extent the standard of intellectual property protection should further become harmonized globally (May and Sell 2005; May 2010). Arguably, the focus on technological competition between states and firms was never more intensive than today.

Innovation, creativity and fast commercialization of inventions are highly valued by governments. This is nothing new as the cases of nineteenth century Germany, Japan and United States show. Today, governments of OECD countries and the BRICS are concerned with technological shortfalls and "indigenous innovation" as they aim to attract multinational companies under (commonly assumed) conditions of highly flexible production networks and a constant threat of relocating high-tech manufacturing. In OECD member countries and emerging economies, typically several ministries, state agencies, and public-private partnerships try to steer, regulate, and stimulate knowledge production, expertise, and inventions. While the controversies mirroring the typical North-South divide for decades increasingly fade, the ascent of technologically and scientifically vibrant developing economies is about to reshape alliances, interdependencies, and the rules of technology transfer and intellectual property rights (Drahos and Braithwaite 2002; Haunss and Shadlen 2009; Yu 2012). Not unlike military revolutions that have reconfigured space and speed (Hart 1946; Virilio 1986), tectonic shifts in the global political economy tend to fuel immense expectations: the possibilities and outcomes of an ever-evolving techno-science appear almost limitless. If anything, the pace with which science becomes entangled with economic competition and state rivalry is accelerating—indeed, acceleration itself may have become a major pattern of markets and politics (Der Derian 1990; Wajcman 2008).

Some IR scholars have long seen this coming. For instance, Keohane and Nye (1977) and Susan Strange (1988) pointed out that technology and knowledge production became the central battleground for state rivalry, replacing territory and population (see Singleton 2008). It became a key theme of the post-Cold War period that states face stronger competition over power and authority from transnational enterprises. Changing their institutions, procedures, and laws, states have

to navigate the networked character of global information society (Luke 1998; Keohane and Nye 1998; Kahler 2009; Gilbert and Helleiner 2013). The increasing control over cyber space and the shaping of cyber security seems to bear out the argument that governments have learned to do so, despite the growing complexity and diversification of agency in global affairs (Herrera 2002; Mayer-Schönberger and Lazer 2007; Mueller 2010). In addition, realists and world system theorists stress dynamics of technological and organizational innovation as central factors behind the rise and fall of hegemonic powers (Buzan 1987; Gilpin 1981; Arrighi 1994). Dependency theorists and Neo-Marxists emphasize the significance of technological differences, capitalist property relations and the division of labor within global production chains for the reproduction of international/world order (Cox 1987; Poulantzas 1978; Rosenberg 2010; Darby 2000). But it is in the work by James N. Rosenau (1990, 2003) on non-linear dynamics that we find the most pronounced concern with techno-social changes with global impact and, arguably, the most challenging conceptual response.

The fate of the state remains the central puzzle for IR scholars in the context of continuous technological innovation and the progress of scientific expertise (Skolnikoff 1993; Drezner 2004; Eriksson and Giacomello 2009; Betz and Stevens 2011). However, the study of technologies and large technical systems, as with many other issue areas, suffers from the "territorial trap": because this common IR mindset foregrounds relations among unitary (territorial) states instead of contextualizing states within different and interlinked local, regional and transnational processes and forms of organization (Agnew 1994), technology is merely added to a prefigured theoretical puzzle. But innovation economists and sociologists generally doubt the merits of a dichotomist approach that locates technologies and technological changes in a vague conceptual region of tensions between sovereign nation-states and global forces (Etzkowitz and Leydesdorff 2000). Studies of European integration, for instance, emphasize the complex interplay of states, spaces and transnational technological systems (Misa and Schot 2005; Brenner 2004). Krige et al. (2013: 4) similarly argue that National Aeronautics and Space Administration (NASA) is typical for large technoscientific undertakings in that it needs to be situated in "transnational or global frameworks, in recognition of the interdependence and interconnectivity of the modern state". It is hardly surprising, that critical reflections within innovation studies, with regard to the analytical treatment of states and technology, run in parallel to respective IR debates:

> Nations and states are important in ways techno-nationalism does not capture, and the international and global dimension is crucial in ways which techno-globalism is ignorant of (. . .). In any case, politics, multinational firms, empire and race were also crucial factors in shaping the use of technology which cut across the national and global divide in complex and changing ways. The nation, the state, and the global, are central to the history of twentieth century technology, but not in the ways the relations are usually understood. We need to rethink not only nation-technology, but technology-state relations, and the place of technology at a global level too (Edgerton 2007: 1).

Arguably, an even more essential hurdle is the widely assumed ontological divide between the realms of environment and technology as well as politics and

nature, that only few scholars in IR have persistantly tried to overcome (but see Camilleri 1996; Litfin 1998; Conca 2004). As the impetus to move away from the *juxtaposition* of politics and technology increasingly gains momentum in various social sciences (cf. Latour 1993; Cronon 1995; Reuss and Cutcliffe 2010), the unease of common conceptual premises becomes particularly acute when turning to some of the central concerns within contemporary global politics. Firstly, research on climate change funded by international organizations seems to challenge the neat separation of socio-political and material-technical realms. This case prompts conceptualizations of politics that do justice to the reality of socio-technical hybridization (Miller and Edwards 2001; Linklater 2009; Edwards 2010). Daniel Deudney notes:

> The human world is now 'global and planetary' due to the explosive transformation over the last several centuries of science-based technology occurring within the geophysical and biophysical features of planet Earth. The natural Earth and its relationship with humans have been massively altered by the vast amplifications in dispersed human agency produced by the emergence and spread of machine-based civilization. The overall result of these changes has been the emergence of a global- and planetary-scale material and social reality that is in some ways similar, but in other important ways radically different, from earlier times. Practices and structures inherited from the pre-global human worlds have not adequately been adjusted to take the new human planetary situation into account (Schouten 2013b).

Secondly, as the notion of the Anthropocene acknowledges that humans have turned into a force of truly planetary magnitude (Dalby 2007), it also reinforces the increasing recognition of myriads of non-state actors. These include NGOs, international organizations, megacities, and further private, commercial, and scientific agencies of all kinds. Their transnational practices, global interactions, and extended technological structures have added a significant new layer to relations between states, and governments and enterprises. Analytically, this requires not just sensitivity for the multiplicity of actors, which is well recognized by research on global governance (Rosenau 1995).[5] Following STS and Geography, it also requires exploring the *complexity of agency* itself. That is, the locus of agency that was usually assumed to lie within individuals, groups, or states moved into hybrid, networked and mediated forms of agential power.[6] Research from fields such as security, energy, environment and elsewhere illustrates that agency is increasingly enriched by *ensembles*, *cyborgs* and *non-human* actors.[7]

Thirdly, the sensitivity for the ambiguity of technology and its multipurposeness as discussed above in the case of nuclear weapons also implies that the political results always remain—despite immense efforts put into simulations and scenario building—*underdetermined*. This is not only due to the mostly unknown socio-

[5] See Nye and Keohane (1971), Rosenau (1990), Murphy (1994), Keck and Sikkink (1998), Sassen (2006, 2001), and Hall and Biersteker (2002).

[6] Bijker et al. (1987), Latour (1987), Haraway (2003), Whatmore (2002), Dittmer (2014).

[7] See Acuto and Curtis (2013), Agathangelou (2010), Krishna (2009), Aradau (2010), Mayer and Schouten (2011), Srnicek (2013) and Squire (2014).

material feedback mechanisms and interlinkages operating at various levels, but results from human ingenuity and creative reappropriations and repurposings of technologies (Connolly 2013; Cole 2013; Barry 2013a). Attempts of understanding and theorizing have to cope with the perpetual twists and contingencies of a full-fledged "technological drama" (Pfaffenberger 1992; Joerges 1999). Hence, carefully analyzing politics of science and technology inevitably prevents one from embracing technological determinism.

Fourthly, a multiplication of actors and the rampant proliferation of novel communication technologies may jointly produce new forms of structural and collective power. The example of big data security and digital surveillance illustrates that those are not captured by concepts such as soft, hard, or discursive power (Ansorge 2011; Singh 2013). On the one hand, common conceptual frameworks of sovereignty are challenged by the fact that governmental agencies function in a highly disaggregated manner in their daily practice within international networks (Slaughter 2004; Drake 2008). On the other hand, recent events show that *individuals, enterprises* and *public agencies* that have gained access to large data troves now possess global power to an unprecedented degree. The enormous leverage of journalists, soldiers, or system administrators becomes fully apparent from the biographies of Chelsea Manning, Julian Assange, and Edward Snowden. The technological means of gathering information and meta-data are rapidly multiplied; it is the number of people with direct access to the ever-widening realm of state secrecies and classified information. Democratic and non-democratic governments alike can do nothing but desperately hunt whistle blowers down. Perhaps, greater difficulties for states arise only from preventing algorithms of malicious or defective software from destroying data processing vital for core social systems including finance, health, energy and defense. As such, unintended consequences of novel technologies and cutting-edge scientific knowledge (see Tenner 1997; Tucker 2012), novel forms of power and temporary monopolies inherently belong to the planetary modernization project, making global politics inexorably entangled with fragile infrastructures and technical risks.

5 Science and Technology: IR's Unrecognized *Subfield*

Shortly after World War II, William F. Ogburn, the editor of the first extensive treatment of "Technology and International Relations," expected that technological change would turn into a major new field of research. Prominent scholars, including Quincy Wright, William T. R. Fox, John Herz, and Bernard Brodie, among others, investigated the impact of various modern technologies on international relations (see Ogborn 1949).[8] The handling of nuclear weapons became the central research

[8] Brian Schmidt's (1998) alternative hagiography of IR indicates that scholars were much earlier quite aware of the importance of technology for world affairs.

concern of a large epistemic community during the 1950s and 1960s. The research agenda turned primarily to the vital issue of nuclear deterrence, (non)proliferation, and super power relations. Other scholars such as James Rosenau, Stephen Krasner, Joseph Nye, Susan Strange, Robert Keohane, and Ernst Haas approached the emerging global cross-border communications and scientific and technological linkages through structural realism, neofunctional integration theory and regime theory. Recently, the number of studies on the political implications of information technologies and the Internet has been growing rapidly (cf. Simmons 2013), reversing a previous "silence" concerning communication technologies.

Yet, while IR scholars have persistently engaged the issue, technologies and sciences did not, become a separate research field on its own, in contrast to Ogburn's expectations. Moreover, given that Sociology, Geography, History, Anthropology, and Archeology, among others, display thriving debates, journals, and entire subfields solely dedicated to technology and science, a relative dearth of research attention in IR is remarkable. Table 1 shows the small number of IR publications explicitly dealing with the subject. Between 1990 and 2007, science and technology were covered by merely 0.7 % out of more than 21,081 published in 13 major IR journals. More importantly, an even tinier fraction genuinely deals with *theorizing* or *conceptualizing* technologies.

In short, these findings underline the assertion that IR has little explored, and much less theorized, the variety of forms of power and sites of politics related to

Table 1 Articles on science and technology published in major IR journals

Journal	Years	Overall number of articles	Articles on 'science' and 'technology'	Percent of all articles
Alternatives: Global, Local, Political	1990–2009	444	18	4,05
Foreign Affairs	1990–2009	7400	28	0,38
Foreign Policy	1990–2009	2174	13	0,60
International Affairs	1990–2007	6105	23	0,38
International Organization	1990–2009	565	6	1,06
International Political Science Review	1990–2009	447	10	2,24
International Security	1990–2007/2008	521	15	2,88
International Studies Quarterly	1990–2007	506	11	2,17
International Studies Review	1990–2007	214	2	0,93
Journal of Conflict Resolution	1990–2009	699	5	0,72
Review of International Studies	1990–2007	545	10	1,83
Third World Quarterly	1990–2007	1199	13	1,08
World Politics	1990–2009	262	2	0,76

Source: Articles were accessed via www.jstor.org database in August/September 2013 (except data on *Millennium* that were provided by SAGE journals homepage). Articles were first selected using keywords such as "science" and "technology" appearing in headlines, abstracts, or the text body. In a next step, items were carefully filtered out on a case-by-case basis concerning issue areas (applied research) and attempts of theorizing

modern sciences and all kinds of technologies (Herrera 2003; Weiss 2005; Peoples 2009). Despite a degree of topical diversification of "applied research", IR is not concerned with how the actual *diversity*, *magnitude*, and *interactions* of technologies co-constitute and reshape what Tim Dant (2006) calls "material civilization". The scope of IR's academic interest neither matches the prominence of science and technology nor the extent to which they generate curiosity outside of IR circles. This seems extraordinary, in particular, when one tries to account for the plethora of emerging and constantly evolving clusters of new and old technologies and large technical systems, not to mention the amount of scientific or technology-centered controversies in contemporary global politics—only few of which we outlined above. Hence, the articulation of science and technology within IR presents a paradox of sorts for it is an "unrecognized field". The question then arises: why the issue failed to gain a central place within IR, especially in terms of theorizing?

To begin with, messiness and complexity inherent to science and technology tends to slip easily through the inter-state matrix structuring much of IR thinking and research. Because different related topics and issues have been raised in divers theoretical contexts, sciences and technologies were usually forced into a straitjacket belonging to *other* debates, concerns, and frameworks. But they have not spurred sustained attention and efforts to theorize in their own right. Another conceptual obstacle is that the study of science and technology became prey to two rivaling views: "technological determinism" and "social constructivism" (cf. Law 1991; Fritsch 2011). The former deems all politics a (by)product of technology and expertise. This kind of determinist assumptions is anathema to social scientists, who focus on social practices, institutions, and norms. Early realist thinkers, for example, refused accepting the right to dictate policies and politics that technologies of total destruction were assumed to possess. They sought to preserve progressive (enlightenment) perspectives on international politics and, above all, the possibility of democratic institutions against notions of technological determinism (see Williams 2013). Numerous IR scholars are siding with Kalevi J. Holsti, denying the idea that technological changes have *any* substantial effects on international affairs:

> (T)he foundational principles of international politics—what we term today the Westphalian system—did not undergo transformation as a result of major changes in the social and technological environment in previous centuries. Diplomatic life in 1775 was not unrecognizable from its predecessor in, let us say, 1700 despite that major intellectual upheaval of the eighteenth century, the Enlightenment. Similarly, the Industrial Revolution, surely a change as momentous as globalization is today, did not reorder major international institutions, except perhaps in the domain of war (Holsti 2004: 19).

As a result, technologies are deprived of their historical significance. At the same time, most approaches to IR are actually dominated by instrumentalist views on technologies (Singh 2002). Social constructivism, liberalism and realism alike tend to picture technologies and sciences as neutral tools. They figure merely in the service of exercising power, realizing interests or carrying meaning. Technology and science, consequently, only possess secondary importance for theoretical explanations and systemic models, encouraging a systematic externalization of

infrastructures, technical networks and other material artifacts. In turn, treating technologies as *deus ex machina* became a recurring practice among IR scholars (Herrera 2003: 569) and has to be understood as flipside of instrumentalism.

Instrumentalism and externalism are both reinforced by an ideational bias at the ontological level of IR theories. For instance, in Kenneth Waltz's classical work Man, the State and War, we encounter a theoretical model that eschews the material world. The perennial problem of IR as such, namely the danger of warfare due to anarchy, is "weightless" to the extent that collective action—that is more or less rational calculation—is played out primarily in human minds (Waltz 1959: 169; Jervis 1988).[9] In Waltz's systemic theory, the material world features merely in the form of "capabilities", which bear on rational calculations by great powers as computable variables (1979).[10] Hedley Bull's *Anarchical Society* similarly pictures the political world exclusively in terms of social practices. Bull sees the international society as a functioning rule-based order. "International order", he proposes, "is order among states; but states are simply groupings of men" (Bull 1977: 20). These examples are not meant to indicate that Waltz's or Bull's approaches display logical inconsistencies but to highlight that these influential works epitomize a mindset within IR, which externalizes science and technology. While representing an essentially social world, material artifacts and infrastructures are not deemed conceptually constitutive to the world assembled in these classical works.

A few IR scholars went to considerable length conceptually in order to acknowledge the existence of material agencies. Regime theory, for instance, was advanced in response to the mutual constraints imposed by nuclear weapons, increased technological interconnections, and trans-boundary flows between nations (Keohane and Nye 1977). Because interdependence "provides opportunities for actors to externalize costs of their actions onto others", Keohane notes that "institutions for global governance will need to limit the negative externalities of decentralized action." (2001: 2) So the intriguing complexity of the technological world, by implication, is reduced to an issue of "beggar thy neighbor". Because -they treat technical systems as "apolitical" and "irrelevant", institutionalist approaches see the design of functioning institutions of governance merely as a *social* problematique (Porter 2003: 524, Pinch 2008). Advancing a neorealist-structural approach, Barry Buzan is among the few who have tried granting technologies a critical role. He suggests that technological progress changes the "interaction capacity", and therefore, the properties of international systems. This explains the historical diversity of system types—an empirical fact that is omitted by Waltz and others who foreground "like-units" neglecting the possibility of differentiation (Buzan et al. 1993, cap. 4).

[9] Although Waltz initially argued that even nuclear weapons are not able to override the constant threat of war between independent sovereign states (Waltz 1959: 235–237), he later claimed that nuclear weapons, aside from bipolarity, secure world peace (Waltz 1990).

[10] Lebow (1994) and Schmidt (2007) detail the difficulties of realist theories, and particularly Waltz's structural realism, to make sense of nuclear weapons and other technologies coherently.

Alexander Wendt also places technology exogenous to a purely social system. Wendt's *Social Theory* rests on a realist meta-theoretical foundation that explicitly acknowledges the existence of an "objective reality". Nevertheless, *intersubjectively* enacted identities are the central domain to order and explain international relations (Zehfuss 2001). Although Went draws on the notion of "interdependence" and "interaction capabilities" to make sense of technological change (Wendt 1999: 243–249), the latter remains a "master variable" off-limits for any theoretical gaze. Poststructuralist scholars also tend to externalize technology by analyzing international relations in terms of "discourses", "speech acts", "subjectivities" or "ideas".[11] Material artifacts are elements of performative processes, however, the very existence of objects (and subjects) is conditioned by discourse (Walker 1993; Campbell 2007).[12] Constructivism and poststructuralism advance a principally similar emphasis: apart from some inescapable constraints of "rump matter", what counts as important for IR is eventually "ideas all the way down" (Wendt 1999: 110). Ultimately it is people who, by attaching meaning to materials—not vice versa—make certain infrastructures, innovative products, or new military items, for instance, more or less relevant (Adler 1997; see Pouliot 2010). Hence, conceptual omission of technologies and sciences can be partly explained by the fact that "both postmodernism and constructivism have been marked by a strong tendency to go too far in their emphasis of the ideational and, by going too far in the search for a pure or nearly pure social ontology."[13]

To summarize, notwithstanding the differences or even incommensurable theoretical positions of Realism, English School, Liberalism, Constructivism and Poststructuralism, these schools found common ground by conceptually externalizing the technological world, while presuming it in their projects. Ideational bias precludes them from substantially contributing to this emerging field. But to sublimate or externalize material agencies is no less common to studies of globalization and world order.[14] The history of technological permeation, composition,

[11] Securitization theory, for instance, eclipses technological or material elements of reality (McDonald 2008).

[12] Poststructuralism nevertheless can involve a subtler reading of materiality than other IR theories would allow for (see Jasanoff 2004b).

[13] Deudney in Schouten (2013b). See also Patomäki and Wight (2000), Buzan (2004).

[14] For instance, David Held et al. (1999) mention in the last pages of their monumental volume *Global Transformations: Politics, Economics and Culture* that "the immense increase in global and regional interactions of all kinds has been supported by a series of transformations in the infrastructures of global interaction." However, they also claim that "the invention of these technologies is not sufficient by itself to account for their deployment, use and growth; but their contribution to both the increased volume and transformed character of contemporary globalization is undeniable." (1999: 428) Apart from a few comments on military infrastructures, *Global Transformations* does not dedicate a single entire page to the technological world. Samuel Huntington's *Clash of Civilizations* is another case in point. While Huntington critically notes that the expansion of the western civilization was owed to military superiority (1997: 51), he prefers to tie his line of arguments into culture, religion, and identity rather than relating it to a technological world.

and remaking of international affairs is widely missing, particularly within systemic theories of IR (Buzan and Lawson 2013; Schouten 2013a; Mayer 2014). Hence, a broader understanding of the global politics of science and technology not just requires the integration of traditional notions and approaches into more comprehensive analytical frameworks. New concepts, approaches and perspectives need to be developed, perhaps under the notion of "integrative pluralism" (Dunne et al. 2013). A more comprehensive analytical toolbox enables incorporating an enormous panorama of empirical materials, cases, and puzzles into the subfield. Thus, far from approaching its endpoint, IR theory is challenged and inspired.

6 Approaching the Global Politics of Science and Technology

The discipline of IR is an outlier. In comparison to other social sciences, it seems much less aware of the extraordinary extent to which (global) politics evolve through sciences and technologies.[15] Nonetheless, decades of innovative research have accumulated a large body of knowledge. Given this condition, it is crucial to incorporate empirical insights and theoretical notions from other disciplines. Making the existing disciplinary boundaries more flexible will make a major contribution to the subfield and to IR in general (see Buzan and Little 2001). Interdisciplinary conversations help to deepen and differentiate IR's understanding of science and technology, both theoretically and analytically (see Bray 2012; Barry 2013b). In this sense, both practitioners and students of the global politics of science and technology might greatly benefit from mutual learning and by reflectively absorbing a rich tradition of debates, puzzles and methods of neighboring disciplines.

The notion of "techno-politics" (Mitchell 2002; Hecht 1998) provides a promising vantage point for this purpose by enhancing IR's vocabulary and perspectives on science and technology. For one, the term can be employed as a boundary concept—a relay between dissimilar disciplinary terminologies as well as confusingly overlapping research agendas and methods. For another, techno-politics functions as an umbrella. Instead of conveying a single definition, it suggests a range of different conceptualizations of technology and science. Their common denominator is a focus on the "middle zone" that covers to deserted area between technological determinism and social constructivism.[16] The occupation and widening of this zone is achieved through the integration of IR and non-IR approaches.

[15] For respective compilations in STS see Jasanoff et al. (1995); for History see Krige and Barth (2006); for political theory see Braun and Whatmore (2010); for Geography see Brunn et al. (2004); for Anthropology see Star (1999) and Stroeken (2013); for Philosophy see Scharff et al. (2013).

[16] See Herrera (2003) and Fritsch (2014, in this volume) for an elaboration of this argument.

It represents, in the view of the editors, the best choice to stimulate a productive theoretical discourse and innovative empirical research. The following conceptually structured set of examples indicates how studying the global politics of science and technology might shed fresh light on existing puzzles within IR and contributes to ongoing debates about ontology and methodology that currently structure the discipline.

- *Constructivist studies of technology* are perhaps the most obvious entry point for IR approaches (cf. Bijker 1993; Ruggie 1993). Here, the notion of technopolitics challenges the instrumentalist idea that social actors can simply attach "meaning" to technological artifacts that, in reverse, turn into powerful carriers of identity or simply express social norms. For instance, Herrera's work on large technological systems (2006), Der Derian's studies of global war and media (2003) and Biggs' (1999) and Branch's (2011) exploration of mapping technologies in the context of early modern state formation show an intricate historical interplay of meaning, representation, and emerging technical practices. Recently, the surge of recording devices, online content, and communication data related to the Internet significantly complicates processes of signification, perceptions and the fixation of intersubjective meaning. In addition, technopolitics imply that scientific practices, epistemic communities and technical designs are not just objective and neutral phenomena but deeply interwoven with the fabric of power (Litfin 1994, Adler and Bernstein 2005). While generations of IR scholars have dealt with the role of scientific knowledge for international politics,[17] it is literature inspired by the "practice turn" in IR,[18] which speaks most immediately to core issues raised in constructivist studies of technology and science. Objective knowledge and technical standards are enmeshed in cultural traditions, ideological views and partly products of political struggles as MacKenzie's famous study on nuclear missile guidance (1993) and Susan Greenhalgh's analysis of China's one-child policy (2008) stress. In the same vein, Sheila Jasanoff's work reinforces symmetrical understandings. Suggesting the idiom of co-production, she "calls attention to the social dimensions of cognitive commitments and understandings, while at the same time underscoring the epistemic and materials correlates of social formations" (Jasanoff 2004a: 3). Christian Reus-Smit's (1996) critical analysis of technological and economic progress as the modern "state purpose", functioning as master narrative of International Society, could open up a symmetrical-constructivist perspective on global order. Similarly the constitution of markets for novel technologies such as nanotechnologies also depends on a fragile, yet powerful co-production of technical expertise on risks, hegemonic practices and public controversies.[19] In this sense, even oceans are subject to enormous construction efforts and, hence, historically evolving hybrids (Steinberg 2001).

[17] See Bueger (2014, in this volume) for an overview.

[18] See Adler and Pouliot (2011), Bigo (2011), Bueger (2013).

[19] See Wullweber (2014, in this volume) for an overview.

- *Assemblage approaches* emphasize complexity, turning global infrastructures, networks, and often overlapping socio-technical ensembles into primary objects of inquiry. Vantage point is the empirical observation that "politics" and "the economy" *emerge* from a messy density. As a consequence, observers cannot priori distinguish between "social" and "material" (Latour 2005). Following Michel Foucault seminal insights, (global) governance is seen as a process of stabilization and ordering though logistical devices, data and various technologies of inscriptions (Foucault 1991; Rose and Miller 1992; Larner and Walters 2004). It is in this sense that "emergence" is key to rearticulating both the agent-structure problem and the ideal-material divide of international affairs beset with techno-politics:

  > techno-politics is always a technical body, an alloy that must emerge from a process of manufacture whose ingredients are both human and nonhuman, both intentional and not, and in which the intentional or the human is always somewhat overrun by the unintended. But it is a particular form of manufacturing, a certain way of organizing the amalgam of human and nonhuman, things and ideas, so that the human, the intellectual, the realm of intentions and ideas seems to come first and to control and organize the nonhuman (Mitchell 2002: 42–43).

Although intimate links exist between modern state formation and infrastructure (Mann 1984), large technical systems, often stretching across the planet, as well as the technological zones that facilitate production, trade, finance, communication, surveillance, and weapon systems are far more complex, multi-sited, and interconnected than any state-centric framework of social collective action allows for (Porter 2003; Sassen 2006; Barry 2006).[20] Assemblage theories, in addition, point out different ways how infrastructures and material inscriptions can wield power. Latour (1987), Mann (2008) and Agnew (2005) suggest that they allow for "acting at a distance" and are co-generative of uneven political space and asymmetric power distribution.[21] For example, the successful European integration is increasingly understood through the lens of transnational infrastructures, including railways, river management, electricity grids, roads, border protection, common currency and so fourth that have immensely contributed to the *materializing* of unification (Barry 2001; Badenoch and Fickers 2010). From a similar perspective, Ruth Oldenziel (2011) and Bélanger and Arroyo (2012) show the crucial importance of hundreds of tiny islands and strategic sites for the logistical maintenance of global surveillance and defense installations underpinning the US empire's use of military force. Stuart Elden's (2013) notion of "vertical geopolitics" indicates how the "depth" of power and influence can be structured through infrastructures such as sewage tunnels, roads, digital networks and so fourth. Even power grids can be deliberately constructed and utilized as instrument of infrastructural oppression (Shamir 2013). In short, this group of conceptual approaches translates into IR

[20] In particular, studies of global air traffic, airports and border technologies exemplify the fruitfulness of this line of inquiry within IR (cf. Salter 2007; Bellanova and Duez 2012; Schouten 2014; Bigo 2014).

[21] An insight, that speaks to early *realist explorations* of spatiality and power (e.g. Carr 1942; Ogborn 1949).

approaches, which do not just emphasize "things", but highlight the variety of non-human agencies without becoming determinist (Latour 1992; Steinberg 2013; Acuto and Curtis 2013; Salter and Mark 2014).

- *Critical and subaltern approaches* stress scientific and technological dimensions of core IR themes such as security, warfare, anarchy, and capitalism (Agathangelou and Ling 2009; Grovogui 1996; Sabaratnam 2011); for instance, the intimate link between Cold War strategic priorities and the transfer of scientific and technical know-how in agriculture to developing countries (Perkins 1997; McNeill and Unger 2010). Critical studies of capitalist reconfigurations of scientific research and progress center around the translation and valorization of knowledge and human bodies in global biomedical markets (Sunder Rajan 2012; Cooper 2008). Gabrielle Hecht (2010) illustrates the shifting ontology of nuclearity and its consequences for post-colonial spaces. James Der Derian and others critically document a fundamental remaking, that is, virtualization of warfare and terror at the nexus of images, entertainment and communication technologies (Der Derian 2009; see also Dillon 2003; Bratton 2009). William Walters (2009) demonstrates the crucial, yet deliberately hidden, role that complex layers of surveillance and border control technologies play for prohibiting (and co-producing) the flow of illegal migration. Critical liberal approaches to drones technology scrutinize the connection between asymmetric warfare and democratic institutions. This latter strand links IR theorizing to the concerns of pragmatist philosophy by John Dewey (1927), who critically examined the interplay of democratic mass societies and emerging media technology (Marres 2007). Furthermore, critical studies converge with constructivist approaches in deciphering and challenging the ways in which technology (and science) is turned into (and misused as) an ideology in the service of powerful commercial, political, or military elites (see Aronowitz 1988; Price 2011).
- Approaches to *technology-based power* raise the diversity and paradoxes of techno-political power shifts, influence and control. Reviel Netz's (2004) account of barbed wire as the quintessential modern power instrument, prohibiting human movements and creating new spaces of control, exemplifies the surprising global effects of a seemingly mundane and local technology. With respect to the Internet, Laura DeNardis' (2014) exploration of its complex material dimensions has, for example, uncovered the infrastructural layers subjected to power struggles. Explorations of time and speed as dimensions of power and governance also show the intricacies of metropolitan and transnational realities technologies help to generate (Thrift 1996; Kern 2003; Nanni 2012). As has already been noted, not even military technologies can be simply reduced to their instrumental functions. The technical design employed by governments does not necessarily lend itself to the intended tactical or strategic goals (Adas 2006: 281ff.). The pervasiveness of multi-layered path-dependencies and unintended consequences of technological systems require, if at all, a highly sophisticated understanding of "causation" (Heilbroner 1994; Hutchby 2001; Feenberg 2010). Conceptualizations, in turn, have to capture more subtle

differences than a broad correlation between major weapon systems and specific sets of security practices (Deudney 2000). Numerous vehicles—from specific technologies to the philosophy of science—are in *differing ways* highly significant for the exercise of (state) power (e.g. Reisch 2005; Innis 2008). Holistic versions of medium theory may offer a way to study how evolving communication technologies led to a digitally structured world order (Deibert 1997; Poe 2011). The ramifications of the ubiquity of recording devices are perhaps the best illustration of the paradoxes of "technological power": intelligence services of five aligned states ("five eyes") and several telecommunication enterprises now possess historically unparalleled surveillance capabilities, while whistle blowing individuals have equally unparalleled leverage in world affairs. The advent of a massive global "surveillance industrial complex" (Gray 2014) necessitates a sustained engagement between IR and scholarship in surveillance studies (see Lyon 2007; Green 1999).

- Infusing conceptualizations of techno-politics into *International Political Economy* leads to approaches that zoom in at technological macro-processes and micro practices that create and stabilize "the world economy". Çalışkan's and Callon's (2009) notion of "economization", Gavin Bridge's (2010) analysis of technological shifts in the carbon economy, and the fusion of sociology and STS to study financial markets and the economy in general (Knorr Cetina and Preda 2004; Pinch and Swedberg 2008) are indicative of the crucial importance of local agency and connected infrastructures that "perform" resources, markets, growth, and prizes. Craig N. Murphy and JoAnne Yates (2009) capture the significance that the rapid evolution of global container infrastructures, technical standards and related business models had in establishing the explosion of world trade after the 1960s. Peter Drahos (2010) illustrates the enormous amount of intimate technocratic cooperation between national patent bureaucracies and multinational enterprises that is required to construct a working global system for the protection of intellectual property. Sensitivity for contextual nuance, meticulous detail, and thick empirical description refers back to Karl Marx's work. As a careful anthropologist of technological change, Marx saw machines and infrastructures not only as tools of capitalist exploitation and oppression, but also as generative for the liberation and empowerment of the masses (see Matthewman 2011: 29–49). Analytical perspectives such as the technology club approach (Castellacci and Archibugi 2008), creative destruction (Acemoglu and Robinson 2012), and the digital divide (Norris 2001; Youngs 2007) capture the amplification of techno-political asymmetries in a globalized world. In addition, transnational cultural industries, arts, design and virtual worlds such as video games embody new politico-technical practices and institutions that underlay (and arise from) the commercialization of imaginations of values, identity, and warfare (Dyer-Witheford and De Peuter 2009; Singh 2010). Another major theme is the contingent dynamics of innovations processes and their impact on the formulation and success of industrial and innovation policies. National innovation systems have to operate within a basically global system (Etzkowitz and Leydesdorff 2000). Standard setting, technological monopolies,

trade barriers and migration dynamics exert enormous influence on catching up of emerging economies.[22]

These examples are not meant to present a comprehensive and ultimate mapping of the subfield of the global politics of sciences and technologies. Instead, they exemplify ways in which the notion of techno-politics can function as umbrella of various IR approaches that do justice to the highly complex, hybrid, and dynamic character of the subject matter. Widening and exploring the conceptual zone that transcends technological determinism and social constructivism is most conducive for further theorizing as well as interdisciplinary exchanges. In this sense, the double volume *The Global Politics of Science and Technology* raises multiple related perspectives, concepts, approaches, issue areas, and methods.

The first book summarizes time-tested approaches for studying global politics of science and technology from an IR perspective. The structured overviews in the first part include: three generations of research on experts and scientific expertise in international relations (*Christian Bueger*); postsructuralist, Gramscian, and Marxian studies of hegemony, discourse, and political economy (*Joscha Wullweber*); a conceptual analysis of the place of technology within the main theoretical schools of IR (*Stefan Fritsch*); the evolution and management of nuclear weapon technologies (*Joe Pilat*); the interplay of cyberspace, states, and international anarchy (*Chris C. Demchack* and *Peter Dombrowski*). The second part provides empirical, theoretical, and conceptual interventions from Geography (*Peter Hugill*), History (*Douglas Howland, John Krige*), Innovation Studies (*Daniele Archibugi and Andrea Filippetti*), and Science and Technology Studies (*Sheila Jasanoff*) in order to rearticulate and reframe IR approaches. The final part consists of five interviews. *Loet Leydesdorff, Gabrielle Hecht, Dirk Messner, Timothy Mitchell* and *Karen Litfin* address various empirical and theoretical aspects and possibilities of cross- and multidisciplinary collaboration. Thereby, a space for mutual learning is carved out to work towards understanding the canvass of the global politics of science and technology.

The second book features a collection of issue areas, actors, and cases, advancing IR research on science and technology. Besides detailed empirical studies, it aims at offering a toolbox that entails theoretical perspectives and analytical frameworks transcending both technical determinism and social constructivism.[23] The first part contains *interactional* approaches that inquire into the relevance and consequences of science and technology for the pursuit of foreign policy, regionalization, and international relations. The chapters of the second part explore *co-production* processes through which sciences and technologies become generative for the *emergence* of collective action and new entities, processes and actors.

Acknowledgment The authors are thankful to Douglas Howland, Anna Agathangelou, Peer Schouten, and Christian Bueger for their insightful comments and helpful suggestions. They were instrumental for writing this introductory chapter.

[22] E.g. Stopford et al. (1991), Chang (2002), Hugill and Bachmann (2005), Breznitz (2007).

[23] The introduction of the companion volume provides detailed chapter summaries.

References

Acemoglu, D., & Robinson, J. A. (2012). *Why nations fail: The origins of power, prosperity, and poverty*. New York: Crown.

Acuto, M., & Curtis, S. (Eds.). (2013). *Reassembling international theory: Assemblage thinking and international relations*. London: Palgrave Macmillan.

Adas, M. (1989). *Machines as the measure of men: Science, technology, and ideologies of western dominance*. Ithaca, NY: Cornell University Press.

Adas, M. (1997). On science technology and colonial expansion and dominance of European states: A field matures: Technology, science, and western colonialism. *Technology and Culture, 38*(2), 478–487.

Adas, M. (2006). *Dominance by design: Technological imperatives and America's civilizing mission*. Cambridge, MA: Harvard University Press.

Adler, E. (1997). Seizing the middle ground: constructivism in world politics. *European Journal of International Relations, 3*(3), 319–363.

Adler, E., & Pouliot, V. (2011). International practices. *International Theory, 3*(1), 1–36.

Adler, E., & Bernstein, S. (2005). Knowledge in power: The epistemic construction of global governance. In M. Barnett & R. Duvall (Eds.), *Power and global governance* (pp. 294–318). Cambridge, MA: Cambridge University Press.

Agathangelou, A. M. (2010). Bodies of desire, terror and the war in Eurasia: Impolite disruptions of (neo) liberal internationalism, neoconservatism and the 'new' Imperium. *Millennium Journal of International Studies, 38*(3), 693–722.

Agathangelou, A. M., & Ling, L. H. M. (2009). *Transforming world politics: From empire to multiple worlds*. London: Routledge.

Agnew, J. (1994). The territorial trap: The geographical assumptions of international relations theory. *Review of International Political Economy, 1*(1), 53–80.

Agnew, J. (2005). Sovereignty regimes: Territoriality and state authority in contemporary world politics. *Annals of the Association of American Geographers, 95*(2), 437–461.

Ansorge, J. T. (2011). Digital power in world politics: Databases, panopticons. *Millennium Journal of International Studies, 40*(1), 65–83.

Aradau, C. (2010). Security that matters: Critical infrastructure and objects of protection. *Security Dialogue, 41*(5), 491–514.

Arkin, R. C. (2010). The case for ethical autonomy in unmanned systems. *Journal of Military Ethics, 9*(4), 332–341.

Aronowitz, S. (1988). *Science as power: Discourse and ideology in modern society*. Minneapolis: University of Minnesota Press.

Arrighi, G. (1994). *The long twentieth century: Money, power, and the origins of our times*. New York: Verso.

Badenoch, A., & Fickers, A. (Eds.). (2010). *Materializing Europe: Transnational infrastructures and the project of Europe*. London: Palgrave Macmillan.

Barry, A. (2001). *Political machines: Governing a technological society*. London: Athlone.

Barry, A. (2006). Technological zones. *European Journal of Social Theory, 9*(2), 239–253.

Barry, A. (2013a). *Material politics: Disputes along the pipeline*. New York: Wiley.

Barry, A. (2013b). The translation zone: Between actor-network theory and international relations. *Millennium: Journal of International Studies, 41*(3), 413–429.

Bauman, Z. (2013). *Modernity and the holocaust*. Hoboken, NJ: Wiley.

Bauman, Z., Bigo, D., Esteves, P., Guild, E., Jabri, V., Lyon, D., et al. (2014). After snowden: Rethinking the impact of surveillance. *International Political Sociology, 8*(2), 121–144.

Bayly, C. A. (2004). *The birth of the modern world, 1780-1914: Global connections and comparisons*. Oxford: Blackwell.

Bélanger, P., & Arroyo, A. S. (2012). Logistics Islands: The global supply archipelago and the topologics of defense. *Prism, 3*(4), 54–75.

Bellanova, R., & Duez, D. (2012). A different view on the 'making' of European security: The EU Passenger Name Record System as a socio-technical assemblage. *European Foreign Affairs Review, 17*(Special Issue), 109–124.

Berman, M. (1983). *All that is solid melts into air: The experience of modernity*. London: Verso.

Biggs, M. (1999). Putting the state on the map: Cartography, territory, and European state formation. *Comparative Studies in Society and History, 41*(2), 374–405.

Bigo, D. (2011). Pierre Bourdieu and international relations: Power of practices, practices of power. *International Political Sociology, 5*(3), 225–258.

Bigo, D. (2014). The (in)securitization practices of the three universes of EU border control: Military/Navy-border guards/police-database analysts. *Security Dialogue, 45*(3), 209–225.

Bijker, W. E., Hughes, T. P., & Trevor Pinch, J. (Eds.). (1987). *The social construction of technological systems: New directions in the sociology and history of technology*. Cambridge, MA: MIT Press.

Bijker, W. E. (1993). Do not despair: There is life after constructivism. *Science, Technology and Human Values, 18*(1), 113–138.

Beck, U. (1992). *Risk society: Towards a new modernity*. New Delhi: Sage.

Beck, U., Giddens, A., & Lash, S. (1994). *Reflexive modernization: Politics, tradition and aesthetics in the modern social order*. Stanford: Stanford University Press.

Betz, D., & Stevens, T. (2011). *Cyberspace and the state: Toward a strategy for cyber-power*. Abingdon; New York: Routledge.

Bollier, D. (2010). *The promise and peril of big data*. Washington, DC: The Aspen Institute.

Bousquet, A. J. (2009). *The scientific way of warfare: Order and chaos on the battlefields of modernity*. New York: Columbia University Press.

Branch, J. (2011). Mapping the sovereign state: Technology, authority, and systemic change. *International Organization, 65*(1), 1–36.

Bratton, B. H. (2009). On geoscapes and the Google caliphate reflections on the Mumbai Attacks. *Theory, Culture and Society, 26*(7–8), 329–342.

Braudel, F. (1982). *Civilization and capitalism, 15th-18th century: The perspective of the world* (Vol. 3). Berkeley: University of California Press.

Braun, B., & Whatmore, S. (Eds.). (2010). *Political matter: Technoscience, democracy and public life*. Minneapolis: University of Minnesota Press.

Bray, F. (2012). Only connect: Comparative, national, and global history as frameworks for the history of science and technology in Asia. *East Asian Science, Technology and Society: An International Journal, 6*(2), 233–241.

Brenner, N. (2004). Urban governance and the production of new state spaces in Western Europe, 1960–2000. *Review of International Political Economy, 11*(3), 447–488.

Breznitz, D. (2007). *Innovation and the state*. New Haven, CN: Yale University Press.

Bridge, G. (2010). Geographies of peak oil: The other carbon problem. *Geoforum, 41*(4), 523–530.

Brodie, B. (1946). *The absolute weapon: Atomic power and world order*. New York: Harcourt.

Brunn, S. D., Cutter, S. L., & Harrington, J. W., Jr. (Eds.). (2004). *Geography and technology*. Berlin: Springer.

Bueger, C. (2013). Pathways to practice: Praxiography and international politics. *European Political Science Review, 6*(3), 383–406.

Bull, H. (1977). *The anarchical society: A study of order in world politics*. New York: Columbia University Press.

Buzan, B. (1987). *An introduction to strategic studies: Military technology and international relations*. London: Macmillan.

Buzan, B. (2004). *From international to world society?: English school theory and the social structure of globalization*. Cambridge: Cambridge University Press.

Buzan, B., & Lawson, G. (2013). The global transformation: The nineteenth century and the making of modern international relations. *International Studies Quarterly, 57*(3), 620–634.

Buzan, B., & Hansen, L. (2009). *The evolution of international security studies*. Cambridge, MA: Cambridge University Press.

Buzan, B., & Little, R. (2001). Why international relations has failed as an intellectual project and what to do about it. *Millennium Journal of International Studies, 30*(1), 19–40.
Buzan, B., Jones, C., & Little, R. (1993). *The logic of anarchy*. New York: Columbia University Press.
Byrne, J., & Glover, L. (2005). Ellul and the weather. *Bulletin of Science, Technology and Society, 25*(1), 4–16.
Çalışkan, K., & Callon, M. (2009). Economization, part 1: Shifting attention from the economy towards processes of economization. *Economy and Society, 38*(3), 369–398.
Camilleri, J. (1996). Impoverishment and the national state. In F. Osler & J. Reppy (Eds.), *Earthly goods. Environmental change and social justice* (pp. 122–153). Ithaca: Cornell Univeristy Press.
Campbell, D. (2007). Geopolitics and visuality: Sighting the Darfur conflict. *Political Geography, 26*(4), 357–382.
Carroll, P. (2006). *Science, culture, and modern state formation*. Berkeley: University of California Press.
Castellacci, F., & Archibugi, D. (2008). The technology clubs: The distribution of knowledge across nations. *Research Policy, 37*, 1659–1673.
Castells, M. (1996). *The rise of the network society* (The information age: Economy, society and culture, Vol. 1). Cambridge: Blackwell.
Chandler, A. D. (1977). *The visible hand: The managerial revolution in American business*. Cambridge, MA: Harvard University Press.
Chang, H.-J. (2002). *Kicking away the ladder: Development strategy in historical perspective*. London: Anthem.
Cipolla, C. M. (1965). *Guns, sails and empires: Technological innovation and the early phases of European expansion, 1400-1700*. New York: Pantheon Books.
Cole, D. (2013). Agentic capacities and capacious historical materialism: Thinking with new materialisms in the political sciences. *Millennium Journal of International Studies, 41*(3), 451–469.
Conca, K. (2004). Ecology in an age of empire: A reply to (and extension of) Dalby's imperial thesis. *Global Environmental Politics, 4*(2), 12–19.
Connolly, W. E. (2013). The 'new materialism' and the fragility of things. *Millennium Journal of International Studies, 41*(3), 399–412.
Cooper, M. (2008). *Life as surplus: Biotechnology & capitalism in the Neoliberal era*. Seattle: University of Washington Press.
Cox, R. W. (1987). *Production, power, and world order: Social forces in the making of history*. New York: Columbia University Press.
Creveld, V., & Martin, L. (1993). *Nuclear proliferation and the future of conflict*. New York: Free Press.
Cronon, W. (Ed.). (1995). *Uncommon ground: Rethinking the human place in nature*. New York: W.W. Norton.
Dalby, S. (2007). Anthropocene geopolitics: Globalisation, empire, environment and critique. *Geography Compass, 1*(1), 103–118.
Dant, T. (2006). Material civilization: Things and society. *The British Journal of Sociology, 57*(2), 289–308.
Darby, P. (Ed.). (2000). *At the edge of international relations: Postcolonialism, gender and dependency*. London/New York: Continuum.
Deibert, R. J. (1997). *Parchment, printing, and hypermedia: Communication in world order transformation*. New York: Columbia University Press.
Deibert, R., Palfrey, J., Rohozinski, R., & Zittrain, J. (Eds.). (2010). *Access controlled: The shaping of power, rights, and rule in cyberspace*. Cambridge, MA: MIT Press.
Delanda, M. (1991). *War in the age of intelligent machines*. New York: Zone Books.
De Nardis, L. (2014). *The global war for internet governance*. New Haven: Yale University Press.

Der Derian, J. (1990). The (S)pace of international relations: Simulation, surveillance, and speed. *International Studies Quarterly, 34*(3), 295–310.
Der Derian, J. (2003). The question of information technology in international relations. *Millennium Journal of International Studies, 32*(3), 441–456.
Der Derian, J. (2009). *Virtuous war: Mapping the military-industrial-media-entertainment-network*. London: Routledge.
Deudney, D. (2000). Geopolitics as theory: Historical security materialism. *European Journal of International Relations, 6*(1), 77–107.
Dewey, J. (1927). *The public and its problems*. Ohio: Ohio University Press.
Dillon, M. (2003). Virtual security: A life science of (dis) order. *Millennium Journal of International Studies, 32*(3), 531–558.
Dinerstein, J. (2006). Technology and its discontents: On the verge of the posthuman. *American Quarterly, 58*(3), 569–595.
Dittmer, J. (2014). Geopolitical assemblages and complexity. *Progress in Human Geography, 38* (3), 385–401.
Drahos, P. (2010). *The global governance of knowledge: Patent offices and their clients*. Cambridge, MA: Cambridge University Press.
Drahos, P., & Braithwaite, J. (2002). *Information feudalism: Who owns the knowledge economy?* London: Earthscan.
Drake, W. J., & Wilson, E. J. (Eds.). (2008). *Governing global electronic networks. International perspectives on policy and power*. Cambridge, MA: The MIT Press.
Drezner, D. W. (2004). The global governance of the internet: Bringing the state back in. *Political Science Quarterly, 119*(3), 477–498.
Dyer-Witheford, N., & De Peuter, G. (2009). *Games of empire: Global capitalism and video games*. Minneapolis, MN: University of Minnesota Press.
Dunne, T., Hansen, L., & Wight, C. (2013). The end of International Relations theory? *European Journal of International Relations, 19*(03), 405–425.
Edgerton, D. E. H. (2007). The contradictions of techno-nationalism and techno-globalism: A historical perspective. *New Global Studies, 1*(1), 1–32.
Edwards, P. N. (1997). *The closed world: Computers and the politics of discourse in Cold War America*. Cambridge: MIT Press.
Edwards, P. N. (2010). *A vast machine: Computer models, climate data, and the politics of global warming*. Cambridge, MA: MIT Press.
Eriksson, J., & Giacomello, G. (2009). Who controls the Internet? Beyond the obstinacy or obsolescence of the state. *International Studies Review, 11*(1), 205–230.
Elden, S. (2013). Secure the volume: Vertical geopolitics and the depth of power. *Political Geography, 34*, 35–51.
Endres, D. (2009). The rhetoric of nuclear colonialism: Rhetorical exclusion of American Indian arguments in the Yucca Mountain nuclear waste siting decision. *Communication and Critical/ Cultural Studies, 6*(1), 39–60.
Etzkowitz, H., & Leydesdorff, L. (2000). The dynamics of innovation: From National Systems and 'Mode 2' to a Triple Helix of university–industry–government relations. *Research Policy, 29* (2), 109–123.
Feenberg, A. (1999). *Questioning technology*. East Sussex: Psychology Press.
Feenberg, A. (2010). *Between reason and experience: Essays in technology and modernity*. Cambridge, MA: MIT Press.
Foucault, M. (1991). *Discipline and punish. The birth of the prison*. London: Penguin.
Frank, A. G. (1998). *ReOrient: Global economy in the Asian age*. Berkeley: University of California Press.
Freedman, L. (2003). *The evolution of nuclear strategy*. London: Palgrave Macmillan.
Friedman, T. (2009). *The world is flat. The globalized world in the twenty first century*. London: Penguin.

Fritsch, S. (2011). Technology and global affairs. *International Studies Perspectives, 12*(1), 27–45.
Gavin, F. J. (2012). *Nuclear statecraft: History and strategy in America's atomic age*. Ithaca, NY: Cornell University Press.
Gilbert, E., & Helleiner, E. (Eds.). (2013). *Nation-states and money: The past, present and future of national currencies*. London: Routledge.
Gilpin, R. (1981). *War and change in world politics*. Cambridge, MA: Cambridge University Press.
Gray, J. (2014). The Snowden files: So much more than state surveillance. *Open Democracy*. February 6. http://www.opendemocracy.net/ourkingdom/jonathan-gray/snowden-files-so-much-more-than-state-surveillance. Accessed 19 Feb 2014.
Green, S. (1999). A plague on the panopticon: Surveillance and power in the global information economy. *Information, Communication and Society, 2*(1), 26–44.
Greenhalgh, S. (2008). *Just one child: Science and policy in Deng's China*. Berkeley: University of California Press.
Grovogui, S. N.' Z. (1996). *Sovereigns, quasi sovereigns and Africans: Race and self-determination in international law*. Minneapolis: University of Minnesota Press.
Guldi, J. (2012). *Roads to power: Britain invents the infrastructure state*. Cambridge: Harvard University Press.
Hall, R. B., & Biersteker, T. J. (Eds.). (2002). *The emergence of private authority in global governance*. New York: Cambridge University Press.
Haraway, D. (1991). *Simians, cyborgs, and women: The reinvention of women*. New York: Routledge.
Haraway, D. (2003). Cyborgs to companion species. Reconfiguring Kinship in technoscience. In D. Ihde & E. Selinger (Eds.), *Chasing technoscience: Matrix for materiality* (pp. 58–82). Bloomington: Indiana University Press.
Hart, H. (1946). Technological acceleration and the atomic bomb. *American Sociological Review, 11*(3), 277–293.
Harvey, D. (1990). *The condition of postmodernity: An enquiry into the conditions of cultural change*. Oxford: Blackwell.
Haunss, S., & Shadlen, K. C. (Eds.). (2009). *Politics of intellectual property: Contestation over the ownership, use, and control of knowledge and information*. Northhampton, MA: Edward Elgar.
Headrick, D. (1981). *The tools of empire. Technology and European imperialism in the nineteenth century*. New York: Oxford University Press.
Hecht, G. (1998). *The radiance of France: Nuclear power and national identity after world war II*. Cambridge, MA: MIT Press.
Hecht, G. (2010). The power of nuclear things. *Technology and Culture, 51*(1), 1–30.
Hecht, G. (Ed.). (2011). *Entangled geographies: Empire and technopolitics in the global Cold War*. Cambridge, MA: MIT Press.
Hecht, G. (2012). *Being nuclear: Africans and the global uranium trade*. Cambridge, MA: MIT Press.
Heilbroner, R. (1994). Technological determinism revisited. In M. R. Smith & L. Marx (Eds.), *Does technology drive history? The dilemma of technological determinism* (pp. 67–78). Cambridge, MA: MIT Press.
Held, D., Goldblatt, D., McGrew, A., & Perraton, J. (1999). *Global transformations: Politics, economics and culture*. Stanford: Stanford University Press.
Herrera, G. L. (2002). The politics of bandwidth: International political implications of a global digital information network. *Review of International Studies, 28*(1), 93–122.
Herrera, G. L. (2003). Technology and international systems. *Millennium Journal of International Studies, 32*(3), 559–593.
Herrera, G. (2006). *Technology and international transformation: The railroad, the atom bomb, and the politics of technological change*. Albany: State University of New York Press.
Hoyt, T. D. (2003). Technology and security. In M. E. Brown (Ed.), *New world: Security challenges in the 21st century* (pp. 17–37). Grave, Georgetown: Georgetown University Press.

Holsti, K. J. (2004). *Taming the sovereigns: Institutional change in international politics*. Cambridge, MA: Cambridge University Press.
Hutchby, I. (2001). Technologies, texts and affordances. *Sociology, 35*(2), 441–456.
Hughes, T. P. (2004). *Human-built world: How to think about technology and culture*. Chicago: University of Chicago Press.
Hugill, P. J. (1999). *Global communications since 1844: Geopolitics and technology*. Ann Arbor: University of Michigan.
Hugill, P. J., & Bachmann, V. (2005). The route to the techno-industrial world economy and the transfer of German organic chemistry to America before, during, and immediately after world war I. *Comparative Technology Transfer and Society, 3*(2), 158–186.
Huntington, S. P. (1997). *The clash of civilizations and the remaking of world order*. London: Simon & Schuster.
Innis, H. (1950). *Communication and empire*. Oxford: Oxford University Press.
Innis, H. (2008). *The bias of communication. Second Edition with a new introduction by Alexander J*. Watson, Toronto: University of Toronto Press.
Jasanoff, S. (1990). *The fifth branch: Science advisers as policymakers*. Cambridge, MA: Harvard University Press.
Jasanoff, S. (2003). Technologies of humility: Citizen participation in governing science. *Minerva, 41*(3), 223–244.
Jasanoff, S. (2004a). The idiom of co-production. In J. Sheila (Ed.), *States of knowledge: The co-production of science and social order* (pp. 1–12). London: Routledge.
Jasanoff, S. (2004b). Ordering knowledge, ordering society. In S. Jasanoff (Ed.), *States of knowledge. The co-production of science and social order* (pp. 13–45). London: Routledge.
Jasanoff, S., Markle, G. E., Peterson, J. C., & Pinch, T. (Eds.). (1995). *Handbook of science and technology studies*. London: Sage.
Joerges, B. (1999). Do politics have artefacts? *Social Studies of Science, 29*(3), 411–431.
Jervis, R. (1988). The political effects of nuclear weapons: A comment. *International Security, 13* (2), 80–90.
Jervis, R. (1989). *The meaning of the nuclear revolution: Statecraft and the prospect of Armageddon*. Ithaca, NY: Cornell University Press.
Juma, C. (2010). *The new harvest: Agricultural innovation in Africa*. Oxford: Oxford University Press.
Kaag, J., & Kaufman, W. (2009). Military frameworks: Technological know-how and the legitimization of warfare. *Cambridge Review of International Affairs, 22*(4), 585–606.
Kahler, M. (Ed.). (2009). *Networked politics: Agency, power, and governance*. Ithaca, NY: Cornell University Press.
Keck, M. E., & Sikkink, K. (1998). *Activists beyond borders: Advocacy networks in international politics*. Ithaca, NY: Cornell University Press.
Keohane, R. O. (2001). Governance in a partially globalized world. *American Political Science Review, 95*(1), 1–13.
Keohane, R. O., & Nye, J. S. (1977). *Power and interdependence: World politics in transition*. Boston: Little, Brown.
Keohane, R. O., & Nye, J. S. (1998). Power and interdependence in the information age. *Foreign Affairs, 77*(5), 81–94.
Kern, S. (2003). *The culture of time and space 1880-1918*. Cambridge, MA: Harvard University Press.
Kevles, D. J. (1977). The national science foundation and the debate over postwar research policy, 1942–1945: A political interpretation of science–the endless frontier. *Isis, 68*(1), 4–26.
Knorr Cetina, K., & Preda, A. (2004). *The sociology of financial markets*. New York: Oxford University Press.
Krige, J. (2006). *American hegemony and the postwar reconstruction of science in Europe*. Cambridge, MA: MIT Press.

Krige, J., Callahan, A. L., & Maharaj, A. (2013). *NASA in the world: Fifty years of international collaboration in space*. New York: Macmillan.
Krige, J., & Barth, K.-H. (Eds.). (2006). *Global power knowledge: Science and technology in international affairs*. Chicago: University of Chicago Press.
Krishna, S. (2009). The social life of a bomb: India and the ontology of an 'overpopulated' society. In I. Abraham (Ed.), *South Asian cultures of the bomb: Atomic publics and state in India and Pakistan* (pp. 68–88). Bloomington: Indiana University Press.
Kurzweil, R. (2006). *The singularity is near: When humans transcend biology*. New York: Viking.
Larner, W., & Walters, W. (Eds.). (2004). *Global governmentality: Governing international spaces*. Oxon: Routledge.
Latour, B. (1987). *Science in action: How to follow scientists and engineers through society*. Cambridge, MA: Harvard University Press.
Latour, B. (1992). Where are the missing masses? The sociology of a few mundane artifacts. In W. E. Bijker & J. Law (Eds.), *Shaping technology/building society: Studies in sociotechnical change* (pp. 225–58). Cambridge, MA: MIT.
Latour, B. (1993). *We have never been modern*. Cambridge, MA: Harvard University Press.
Latour, B. (2005). *Reassembling the social-an introduction to actor-network-theory*. New York: Oxford University Press.
Law, J. (1991). *A sociology of monsters: Essays on power, technology, and domination*. London: Routledge.
Lebow, R. N. (1994). The long peace, the end of the cold war, and the failure of realism. *International Organization, 48*(2), 249–277.
Lear, L. J. (1993). Rachel Carson's "silent spring". *Environmental History Review, 17*(2), 23–48.
Linklater, A. (2009). Human interconnectedness. *International Relations, 23*(3), 481–497.
Litfin, K. T. (1994). *Ozon discourses. Science and politics in global environmental cooperation*. New York: Columbia University Press.
Litfin, K. T. (1998). *The greening of sovereignty in world politics*. Cambridge, MA: The MIT Press.
Luke, T. W. (1998). Running flat out on the road ahead: nationality, sovereignty, and territoriality in the world of the information superhighway. In G. Ó. Tuathail & S. Dalby (Eds.), *Rethinking geopolitics* (pp. 175–212). London: Routledge.
Lyon, D. (2007). *Surveillance studies: An overview*. New York: Polity.
Mackinder, H. J. (1904). The geographical pivot of history. *The Geographical Journal, 23*(4), 421–437.
MacKenzie, D. A. (1993). *Inventing accuracy: An historical sociology of nuclear missile guidance*. Cambridge, MA: MIT Press.
MacKinnon, R. (2013). *Consent of the networked: The worldwide struggle for internet freedom*. New York: Perseus.
Makhijani, A., Howard, H., & Yih, K. (Eds.). (2000). *Nuclear wastelands: A global guide to nuclear weapons production and its health and environmental effects*. Cambridge, MA: MIT Press.
Mann, M. (1984). The autonomous power of the state: Its origins, mechanisms and results. *European Journal of Sociology, 25*(2), 185–213.
Mann, M. (2008). Infrastructural power revisited. *Studies in Comparative International Development, 43*(3), 355–365.
Matthewman, S. (2011). *Technology and social theory*. Basingstoke: Macmillan.
Marres, N. (2007). The issues deserve more credit pragmatist contributions to the study of public involvement in controversy. *Social Studies of Science, 37*(5), 759–780.
May, C. (2010). *The global political economy of intellectual property rights. The new enclosures* (2nd ed.). London: Routledge.
May, C., & Sell, S. K. (2005). *Intellectual property rights. A critical history*. London: Boulder.
Mayer, M. (2014). *The unbearable lightness of international relations – technological innovations, creative destruction, and explorative realism*. Berlin: Springer.

Mayer, M., & Schouten, P. (2011). Energy security and climate security under conditions of the Anthropocene. In L. Anceschi & J. Symons (Eds.), *Energy security in the era of the climate change. The Asia-Pacific experience* (pp. 13–35). London: Palgrave Macmillan.
Mayer-Schönberger, V., & Lazer, D. (Eds.). (2007). *Governance and information technology: From electronic government to information government*. Cambridge, MA: MIT Press.
McDonald, M. (2008). Securitization and the construction of security. *European Journal of International Relations, 14*(4), 563–587.
McLuhan, M., & Powers, B. R. (1992). *The global village: Transformations in world life and media in the 21st century*. New York: Oxford University Press.
McNeill, W. H. (1982). *The pursuit of power. Technology, armed force, and society since A.D. 1000*. Chicago, IL: Chicago University Press.
McNeill, J. R., & Unger, C. R. (Eds.). (2010). *Environmental histories of the cold war*. Cambridge, MA: Cambridge University Press.
Miller, C., & Edwards, P. (Eds.). (2001). *Changing the atmosphere: Expert knowledge and environmental governance*. Cambridge, MA: MIT Press.
Misa, T. J., & Schot, J. (2005). Introduction: Inventing Europe: 1. Technology and the hidden integration of Europe. *History and Technology, 21*(1), 1–19.
Mishra, P. (2012). *From the ruins of empire. Intellectuals who remade Asia*. New York: Farrar Straus & Giroux.
Mitcham, C. (1994). *Thinking through technology: The path between engineering and philosophy*. Chicago, IL: University of Chicago Press.
Mitchell, T. (2002). *Rule of experts: Egypt, techno-politics, modernity*. Berkeley: University of California Press.
Moldaschl, M., & Stehr, N. (Eds.). (2010). *Wissensökonomie und Innovation. Beiträge zur Ökonomie der Wissensgesellschaft*. Marburg: Metropolis.
Morgenthau, H. J. (1964). Modern science and political power. *Columbia Law Review, 64*, 1386–1409.
Morozov, E. (2013). *To save everything, click here: Technology, solutionism, and the urge to fix problems that don't exist*. London: Penguin.
Morozov, E (2014). More political interference! *Frankfurter Allgemeine Zeitung*, 15 Jan 2014. http://www.faz.net/aktuell/feuilleton/medien/evgeny-morozov-s-response-to-sascha-lobo-more-political-interference-12752837.html?printPagedArticle=true. Accessed 19 Feb 2014
Mueller, J. (1988). The essential irrelevance of nuclear weapons: Stability in the postwar World. *International Security, 13*(2), 55–79.
Mueller, J. (1989). *Retreat from doomsday: The obsolescence of major war*. New York: Basic Books.
Mueller, M. L. (2010). *Networks and states. The global politics of Internet governance*. Cambridge, MA: MIT.
Mumford, L. (1966). *The myth of the machine: Technics and human development*. New York: Harcourt Brace.
Murphy, C. N., & Yates, J. A. (2009). *The International Organization for Standardization (ISO): Global governance through voluntary consensus*. London: Routledge.
Murphy, C. N. (1994). *International organization and industrial change: Global governance since 1850. Europe and the international order*. New York: Oxford University Press.
Nanni, G. (2012). *The colonisation of time: Ritual, routine and resistance in the British empire*. Manchester: Manchester University Press.
Nelkin, D. (Ed.). (1992). *Controversy: Politics of technical decisions* (3dth ed.). Newbury Park, CA: Sage.
Netz, R. (2004). *Barbed wire: An the ecology of modernity*. Middletown: Wesleyan University Press.
Norris, P. (2001). *Digital divide: Civic engagement, information poverty, and the Internet worldwide*. Cambridge, MA: Cambridge University Press.

Nye, J. S., & Keohane, R. O. (1971). Transnational relations and world politics: An introduction. *International Organization, 25*(3), 329–349.
Oldenziel, R. (2011). Islands: The United States as a networked empire. In G. Hecht (Ed.), *Entangled geographies: empire and technologies in the global Cold War* (pp. 13–42). Cambridge, MA: MIT.
Ogborn, W. F. (1949). *Technology and international relations*. Chicago, IL: University of Chicago Press.
Osterhammel, J. (2009). *The transformation of the world. A history of the 19th century*. Princeton: Princeton University Press.
Paarlberg, R. L. (2004). Knowledge as power: Science, military dominance, and US security. *International Security, 29*(1), 122–151.
Patomäki, H., & Wight, C. (2000). After postpositivism? The promises of critical realism. *International Studies Quarterly, 44*, 213–237.
Paul, H. W. (2003). *From knowledge to power: The rise of the science empire in France, 1860-1939*. Cambridge, MA: Cambridge University Press.
Peoples, C. (2009). Technology, philosophy and international relations. *Cambridge Review of International Affairs, 22*(4), 559–561.
Perkins, J. H. (1997). *Geopolitics and the green revolution*. Oxford, NY: Oxford University Press.
Pfaffenberger, B. (1992). Social anthropology of technology. *Annual Review of Anthropology, 21*, 491–516.
Pielke, R., Wigley, T., & Green, C. (2008). Dangerous assumptions. *Nature, 452*(7187), 531–532.
Pinch, T., & Swedberg, R. (2008). *Living in a material world: Economic sociology meets science and technology studies* (Vol. 1). Cambridge, MA: MIT.
Pinch, T. (2008). Technology and institutions: Living in a material world. *Theory and Society, 37* (5), 461–483.
Poe, M. T. (2011). *A history of communications: Media and society from the evolution of speech to the internet*. Cambridge: Cambridge University Press.
Porter, T. (2003). Technical collaboration and political conflict in the emerging regime for international financial regulation. *Review of International Political Economy, 10*(3), 520–551.
Potter, S. J. (2007). Webs, networks, and systems: Globalization and the mass media in the nineteenth-and twentieth-century British empire. *The Journal of British Studies, 46*(3), 621–646.
Pouliot, V. (2010). The materials of practice: Nuclear warheads, rhetorical commonplaces and committee meetings in Russian–Atlantic relations. *Cooperation and Conflict, 45*(3), 294–311.
Poulantzas, N. (1978). *State power and socialism*. London: NLB.
Price, D. H. (2011). *Weaponizing anthropology: Social science in service of the militarized state*. Petrolia and Oakland, CA: CounterPunch and AK.
Rasmussen, A. (2014). NATO's new frontier. *World Affairs,* February 11. http://www.project-syndicate.org/commentary/anders-fogh-rasmussen-presents-the-benefits-of-creating-a-european-missile-defense-system. Accessed 02 Feb 2014.
Reisch, G. A. (2005). *How the cold war transformed philosophy of science: to the icy slopes of logic*. Cambridge, MA: Cambridge University Press.
Reus-Smit, C. (1996). The normative structure of international society. In F. Osler & J. Reppy (Eds.), *Earthly goods. Environmental change and social justice* (pp. 196–221). Ithaca: Cornell Univeristy Press.
Reuss, M., & Cutcliffe, S. H. (Eds.). (2010). *The illusory boundary: Environment and technology in history*. Charlottesville: University of Virginia Press.
Richards, E., & Ashmore, M. (1996). More sauce please! The politics of SSK: Neutrality, commitment and beyond. *Social Studies of Science, 26*(2), 219–228.
Ronen, P. (2003). *The offshore world: Sovereign markets, virtual places, and nomad millionaires*. Ithaca: Cornell University Press.
Rose, N. (2007). *The politics of life itself: Biomedicine, power, and subjectivity in the twenty-first century*. Princeton: Princeton University Press.

Rose, N., & Miller, P. (1992). Political power beyond the state: Problematics of government. *British Journal of Sociology, 43*(2), 173–205.
Rosenau, J. N. (1990). *Turbulence in world politics: A theory of change and continuity*. Princeton: Princeton University Press.
Rosenau, J. N. (1995). Governance in the twenty-first century. *Global Governance, 1*(1), 13–43.
Rosenau, J. (2003). *Distant proximities: Dynamics beyond globalization*. Princeton: Princeton University Press.
Rosenau, J. N., & Singh, J. P. (Eds.). (2002). *Information technologies and global politics. The changing scope of power and governance*. Albany: State University of New York Press.
Rosenberg, J. (2010). Basic problems in the theory of uneven and combined development. Part II: unevenness and political multiplicity. *Cambridge Review of International Affairs, 23*(1), 165–189.
Ruggie, J. G. (1993). Territoriality and beyond: Problematizing modernity in international relations. *International Organization, 47*(1), 139–174.
Sabaratnam, M. (2011). IR in dialogue... but can we change the subjects? A typology of decolonising strategies for the study of world politics. *Millennium Journal of International Studies, 39*(3), 781–803.
Sassen, S. (2001). *Global networks, linked cities*. London: Routledge.
Sassen, S. (2006). *Territory, authority, rights: From medieval to global assemblages*. Princeton: Princeton University Press.
Salter, M. B. (2007). Governmentalities of an airport: Heterotopia and confession. *International Political Sociology, 1*(1), 49–66.
Salter, M. B. (Ed.). (2014). *Making things international I: Circulation*. Minneapolis: University of Minnesota Press.
Scharff, R. C., & Dusek, V. (Eds.). (2013). *Philosophy of technology: The technological condition: An anthology*. Hoboken, NJ: Wiley.
Schmidt, B. (1998). *The political discourse of anarchy: A disciplinary history of international relations*. Albany, NY: State University of New York Press.
Schmidt, B. C. (2007). Realist conceptions of power. In F. Berenskoetter & M. J. Williams (Eds.), *Power in world politics* (pp. 43–64). London: Routledge.
Scheuerman, W. E. (2009). Realism and the critique of technology. *Cambridge Review of International Affairs, 22*(4), 563–584.
Schlosser, E. (2013). *Command and control: Nuclear weapons, the Damascus accident, and the illusion of safety*. New York: Penguin.
Schouten, P. (2013a). The materiality of state failure: Social contract theory, infrastructure and governmental power in Congo. *Millennium Journal of International Studies, 41*(3), 553–574.
Schouten, P. (2013b). Theory talk No. 60: Daniel Deudney on mixed ontology, planetary geopolitics, and Republican Greenpeace. http://www.theorytalks.org/2013/11/theory-talk-60_285.html. Accessed 20 Feb 2014
Schouten, P. (2014). Security as controversy: Reassembling security at Amsterdam airport. *Security Dialogue, 45*(1), 23–42.
Scott, J. C. (1998). *Seeing like a state: How certain schemes to improve the human condition have failed*. New Haven: Yale University Press.
Sen, A. K. (1999). *Development as freedom*. Oxford: Oxford University Press.
Shamir, R. (2013). *Current flow: The electrification of palestine*. Stanford, CA: Stanford University Press.
Shapin, S., & Schaffer, S. (1985). *Leviathan and the air-pump: Hobbes, boyle, and the experimental life*. Princeton, NJ: Princeton University Press.
Simmons, B. A. (2013). Preface: International relationships in the information age. *International Studies Review, 15*(1), 1–4.
Singh, J. P. (2002). Introduction: Information technologies and the changing scope of global power and governance. In J. N. Rosenau & J. P. Singh (Eds.), *Information technologies and global politics. The changing scope of power and governance* (pp. 1–38). Albany: State University of New York Press.

Singh, J. P. (Ed.). (2010). *International cultural policies and power*. Basingstoke: Macmillan.
Singh, J. P. (2013). Information technologies, meta-power, and transformations in global politics. *International Studies Review, 15*(1), 5–29.
Singleton, R. (2008). Knowledge and technology: The basis of wealth and power. In D. N. Balaam & M. Veseth (Eds.), *Introduction to international political economy* (4th ed., pp. 196–214). Upper Saddle River, NJ: Prentice Hall.
Skocpol, T., & Rueschemeyer, D. (Eds.). (1996). *States, social knowledge, and the origins of modern social policies*. Princeton, NJ: Princeton University Press.
Skolnikoff, E. B. (1993). *The elusive transformation: Science, technology and the evolution of international politics*. Princeton: Princeton University Press.
Slaughter, A.-M. (2004). *A new world order*. Princeton: Princeton University Press.
Smith, M. R., & Marx, L. (Eds.). (1994). *Does technology drive history? The dilemma of technological determinism*. Cambridge, MA: MIT.
Srnicek, N. (2013): *Representing complexity: The material construction of world politics* (PhD thesis). The London School of Economics and Political Science (LSE).
Squire, V. (2014). Reshaping critical geopolitics? The materialist challenge. *Review of International Studies*. doi:10.1017/S0260210514000102.
Star, S. L. (1999). The ethnography of infrastructure. *American Behavioral Scientist, 43*, 377–391.
Steinberg, P. E. (2001). *The social construction of the ocean*. Cambridge, MA: Cambridge University Press.
Steinberg, P. (2013). Of other seas: Metaphors and materialities in maritime regions. *Atlantic Studies, 10*(2), 156–169.
Stopford, J. M., Strange, S., & Henley, J. S. (1991). *Rival states, rival firms: Competition for world market shares*. Cambridge, MA: Cambridge University Press.
Strange, S. (1988). *State and markets*. London: Bloomsbury Academic.
Strange, S. (1996). *The retreat of the state*. Cambridge, MA: Cambridge University Press.
Stroeken, K. (Ed.). (2013). *War, technology, anthropology*. New York/Oxford: Berghahn Books.
Sunder Rajan, K. (Ed.). (2012). *Lively capital: biotechnologies ethics and governance in global markets*. Durham, NC: Duke University Press.
Tenner, E. (1997). *Why things bite back: Technology and the revenge of unintended consequences*. New York: Vintage.
Thad Allan, M. (2001). Modernity, the holocaust, and machines without history. In A. C. Hughes, M. Thad Allan, & G. Hecht (Eds.), *Technologies of power: Essays in honor of Thomas Parke Hughes and Agatha Chipley Hughes* (pp. 175–214). Cambridge, MA: MIT.
Thrift, N. (1996). *Spatial formations*. London: Sage.
Tucker, J. B. (Ed.). (2012). *Innovation, dual use, and security: Managing the risks of emerging biological and chemical technologies*. Cambridge: MIT Press.
United Nations. (2012). *Big data for development. Challenges and opportunities*. New York: UN Publishing.
United Nations (2013). Statistics and Indicators for the post-2015 development agenda. New York: UN publishing. http://www.un.org/en/development/desa/policy/untaskteam_undf/UNTT_MonitoringReport_WEB.pdf. Accessed 19 Feb 2014
UNESCO. (2005). *Towards knowledge societies*. Paris: UNESCO publishing. http://unesdoc.unesco.org/images/0014/001418/141843e.pdf. Accessed 19 Feb 2014.
Van Munster, R., & Sylvest, C. (2014). Reclaiming nuclear politics? Nuclear realism, the H-bomb and globality. *Security Dialogue* (in press).
Virilio, P. (1986). *Speed and politics: an essay on dromology*. New York: Columbia University.
Virilio, P. (2010). *Grey ecology*. New York: Atropos Press. Translated by Drew Burk.
Wajcman, J. (2008). Life in the fast lane? Towards a sociology of technology and time. *The British Journal of Sociology, 59*(1), 59–77.
Walker, R. B. J. (1993). *Inside/outside: International relations as political theory*. Cambridge, MA: Cambridge University Press.

Walters, W. (2009). Anti-political economy: Cartographies of "illegal immigration" and the displacement of the economy. In J. Best & M. Paterson (Eds.), *Cultural political economy* (pp. 113–138). London: Routledge.
Waltz, K. N. (1959). *Man, the state, and war: A theoretical analysis*. New York: Columbia University Press.
Waltz, K. N. (1979). *Theory of international politics*. Boston: MacGraw-Hill.
Waltz, K. N. (1990). Nuclear myths and political realities. *American Political Science Review, 84* (3), 731–745.
Weiss, C. (2005). Science, technology and international relations. *Technology in Society, 27*(3), 295–313.
Wendt, A. (1999). *Social theory of international politics*. Cambridge, MA: Cambridge University Press.
Whatmore, S. (2002). *Hybrid geographies: Natures cultures spaces*. London: Sage.
Williams, M. C. (2013). In the beginning: The international relations enlightenment and the ends of international relations theory. *European Journal of International Relations, 19*(3), 647–665.
Winner, L. (1980). Do artifacts have politics? *Daedalus, 109*(1), 121–136.
White, L. J. (1966). *Medieval technology and social change*. New York: Oxford University Press.
Wolfe, A. (2013). *Competing with the Soviets: Science, technology, and the state in Cold War America*. Baltimore: John Hopkins University Press.
Woolgar, S., & Cooper, G. (1999). Do artifacts have ambivalence? Moses' bridges, Winner's bridges and other urban legends in S&TS. *Social Studies of Science, 29*(3), 433–449.
Yang, D. (2011). *Technology of empire: Telecommunications and Japanese expansion in Asia, 1883–1945*. Cambridge, MA: Harvard University Asia Center.
Youngs, G. (2007). *Global political economy in the information age: Power and inequality*. London: Routledge.
Yu, P. K. (2012). The rise and decline of intellectual property powers. *Campbell Law Review, 34* (3), 525–577.
Zaheer, B. (1996). *The science of empire: Scientific knowledge, civilization, and colonial rule in India*. Albany: SUNY Press.
Zehfuss, M. (2001). Constructivism and identity: A dangerous liaison. *European Journal of International Relations, 7*(3), 315–348.

http://www.springer.com/978-3-642-55006-5

The Global Politics of Science and Technology - Vol. 1
Concepts from International Relations and Other Disciplines
Mayer, M.; Carpes, M.; Knoblich, R. (Eds.)
2014, XIII, 282 p. 7 illus., 5 illus. in color., Hardcover
ISBN: 978-3-642-55006-5