The Unbearable Lightness of International Relations

Technological Innovations, Creative Destruction and Assemblages

Inaugural-Dissertation

Zur Erlangung der Doktorwürde

der

Philosophischen Fakultät

der

Rheinischen Friedrichs-Wilhelms-Universität

zu Bonn

vorgelegt von

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aus

Lindau am Bodensee

Bonn, 2017

Gedruckt mit der Genehmigung der Philosophischen Fakultät
der Rheinischen Friedrich-Wilhelms-Universität Bonn.

Der urprüngliche Titel dieser Dissertation lautete *How IR might overcome its “lightness” - Technological innovations, creative destruction, and explorative realism.*

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Tag der mündlichen Prüfung: 14. März 2013

Acknowledgements

This book results from my dissertation project. Many colleagues and friends supported me during the process of drafting and editing. I am thankful to all advice, insight and ideas that I gained from these conversations. Furthermore, various people, including first of all my two patient PhD advisors Prof. Xuewu Gu and Prof. Doris Fischer, were instrumental in helping me the articulate my ideas more systematically and clearly. I want to especially thank my friends Peer Schouten, Ruth Knoblich and Douglas Howland for precious hours of discussion and contemplation. I am also indebted to the wonderful students of Bonn University for their critical questions and discussion in several courses. Katarina C. Cramer was so kind to draw some of the visualizations used in this book. Of course, I am responsible for all remaining mistakes, omissions, and inconsistencies in the following pages. So, despite perhaps risking to end up with an incomplete list, many heartfelt thanks go to Xuewu Gu, Doris Fischer, JP Singh, Sheila Jasanoff, Peter Haas, Anna Leander, Maddeline Carr, Rocco Bellanova, Gunhild Hoogensen, Christian Büger, Michele Acuto, Renee Marlin-Bennett, Mikko Huotari, Kristin Shi-Kupfer, Anya Huang, Mascha Gugganig, Sebastian Pfotenhauer, Enrico Fels, Jost Wübbeke, Jan Bachmann, Chuanxing Wang, Stefan Fritsch, Dan Deudney, Frank Tsai, Ping Su, Katharina Kronenberg, Andrej Pustovitovskij, Krystin Unverzagt, Katarina C. Cramer, Dániel Balázs, and last but not least to all of my dear family members who suffered during the time of working on this project.

Summery

How could one oversee the monumental modern landscape that has been created by continuous technological innovations? Notwithstanding a few students of international relations who have insisted in taking notice, technology has remained an exotic subject matter in International Relations theory (IR). While the interest in technologies is recently growing most IR scholarship remains silent: the fact that we live in a fully integrated and interconnected technological world is absent from textbooks and introductions to IR. Neither exists theoretical approaches and paradigmatic debates that are concerned with technologies; nor a specific intra-disciplinary subfield. Against this background, this book explores how technological innovations could be theorized and integrated into IR theories. Revisiting the inroads of theoretical approaches to technologies, it highlights the *lightness* of IR scholarship. I argue that the general framework of IR is untenable because it looks at the world as if there were no materials or rather, as if the pervasive presence of artifacts and infrastructures would have no theoretical relevance for conceptualizing and examining world politics. Drawing on ontological and epistemological understandings from anthropology, innovation economics, and science and technology studies, I take issue with the philosophical foundations of the discipline. The notions, concepts and practices, which ultimately sustain and legitimize this lightness, are interrogated. It is shown that the neglect of technological innovation does not merely result from coincidental intellectual moves. It is rather the result of the "Cartesian complex"—the foundational commitment that renders IR a purely social science that deliberately excludes non-humans and hybrid material modes of agency. A radical refashioning is therefore required to the extent to which IR theory aims to accommodate the highly complex and elusive subject matter of technological innovations. This conceptual catharsis does not primarily touch upon epistemological concerns. What is at stake is the limitation of ontological parameters that sustain IR theories. To make sense of the messy technological landscapes, the material agency, and the technologically mediated practices, the prevailing logocentric wisdom needs to be transcended. Against premature metaphysical closure, this book thus contributes to the task of *ontological expansion*. Firstly, it develops an alternative meta-theoretical foundation coined "explorative realism". A new meta-theoretical matrix is

proposed that renders wider ontological parameters intelligible. Especially, the "double-mixed" zone encourages ontological expansion via notions of heterogeneous agency and process philosophy. This implies that IR scholars avoid treating time, space, knowledge, artificial objects, and built environments as constants but as always croproduced. A coproductive commitment opens up new empirical issues and concerns as well as radically different theoretical puzzles. It also implies overcoming Cartesian dualism, abandoning intentionality-based notions of agency, and forgetting the "level of analysis" assumption. Secondly, this book advances a theoretical toolbox consisting of the interrelated concepts of "assemblages" and "creative destruction". The former term signifies actor-networks entailing both humans and non-humans. The latter captures the ways in which technological innovations alter or destabilize assemblages across all levels through a process of translation. This theoretical vocabulary also reconceptualizes the meaning of "power", "authority" with reference to technological innovations. Three open-ended classifications and three models of creative destruction enable the mapping of magnitudes of translations, the changing size and topologies of assemblages and the shifting power and authority. These efforts to theorize technological innovations, then, support empirical research about global transformations and processes of emergence with a set of conceptual tools that allows locating and systematizing cases, puzzles, and scales in relation to assemblages. The study of technological innovations leads to the discovery of novel empirical landscapes and inspires a creative questioning of IR's foundations. As such, while responding to the dearth of theoretical approaches in IR that make sense of technological innovations, this study contributes to the articulation of both a materialist and a post-Cartesian version of IR.

Metaphorical teaser. *A breeze from the ocean. Imagine a beautiful village, located at an infinite coastline, the home of proud Fishermen. Day by day, these brave men and women catch a share of the abundant sea life. Not having invented boats yet, they use dip nets that are perfect tools for the shallow waters along the beach, the Laguna, and in a pond further inland. The families are consumed with their fishing routines. The community does not spend time pondering the possibility of fishing at sea. You can't hear them lamenting the enclosed realm of their world. Fishing offshore is an anathema since "the blue ocean is the holy domain of the gods. The sea", as the priest of the village says, "is improper for us humans." It must remain restricted, inaccessible, and mysterious because it is a dangerous web where "the fish gods, unknown monsters, and the evil forces that cross humans and animals are dwelling". After all, the very idea of a ship is absent, the maritime is diet rich, and the open sea uncharted anyway—why should these villagers want to set sail at all? Instead, their intense concern—and sometimes bitter quarrels—lies with the methods of getting a better catch out of the designated areas: some fishermen investigate the water quality or marine environment in general; some compare the exact nature and behavior of maritime species; others focus on the interactions among these species. Indeed, even though their critical attention encompasses a rather narrow world around their village, it easily keeps them busy till the evening. Now, imagine what this community refuses to do. How about exploring the open sea, and meeting gods or monsters? Think about this weird anti-social domain, murky and shiny, ungraspable and stormy. A sacred area that the community has left untouched for good reasons. A space unmapped and unlimited, it seems, in extension. Certainly, the fishermen, if they nonetheless decide to depart from the shore, would have to craft new tools. Something akin to boats or rafts, as it were, first of all. But the richness and diversity of sea life would also render their dip nets useless. Going to sea would strongly challenge their know-how of fishing and requires from them to deepen their knowledge about maritime life. Perhaps, they would quickly discover that other fellow humans are shipping as well. They would see large cargo ships, huge drilling platforms, or tiny submarines. Beyond the horizon entire civilizations might loom. Leaving the ponds near their village would alter the fishermen's working methods radically. It would reframe their purpose and identity as a community. Imagine a village and fishermen setting sails.*

Contents

List of tables and figure

1. Introduction: technological innovations and International Relations

The planet is crisscrossed with tunnels, traffic and communication channels, monitoring and surveillance infrastructures; the space and the atmosphere are dotted with flying artifacts; roughly 15.000 passenger aircraft are in service, and 900 operational satellites are currently in orbit. Worldwide, 435 nuclear power plants, 40.000 large dams, and over 2300 coal power plants deliver energy for industrial production, transport and urban life; 1.054 cities have a population exceeding 500.000. Globally, more than 4.700 ski resorts offer their services. Around 30 billion plastic water bottles are sold, of which only 15% get recycled. The systematic 'betonization' of living environments alone consumes 15 billion tons of sand per year, making it a scarce resource. An estimated six billion subscribers use mobile phones while governments are concerned with the supply of rare earth minerals necessary for any computing devices. Mathematical algorithms are responsible for 60-70% of the stock market trade in New York and Frankfurt, replacing traders by automatic orders happening within one-thousandth of a second. As France's central bank warns of the dangers arising from the digital currency Bitcoins, Internet access, online banking and social networks spread quickly even in the most deprived and unstable African countries. Through distribution of various sensory and digital devices and systems, both civilians and solders tend to become cyborgs. Cyber space has turned into the signature battlefield of the new millennium with unknown strategic and security ramifications while NGOs and the UN campaign against the development of "killer robots". Meanwhile, the World Bank, OECD and other powerful institutions call for constant improvements in education, research activities and innovation capacities. Economists, probing into the consequences of technological change, reconsider their entire standard model of economic development. Inventions are carried out across fluid transnational networks, as research laboratories and companies fiercely compete for super-computers, nanotechnologies, genetically modified substances or battery systems. International climate negotiations rely upon simulation models that treat the diversity of cultural, political, technological, economic and physical processes as a set of integrated equations. Nobel Prize winners envision large-scale technological fixes for pressing environmental problems such as climate change, food supply and desertification. Armies around the world employ autonomous squadrons and equip *soldiers with the simulacra of augmented realities; though nuclear arsenals, by now, seemingly prevent great power warfare, keep governments alarmed more than ever due to risks of uncontrolled spread and nuclear accidents. Multinational companies, after testing their newest genetically modified plants on remote islands like Hawaii, subjugate farming activities on a planetary scale to conditions of monoculture. The increased production of biofuels causes price turbulence and a change in regional crop cultures. Novel deep-sea drilling and hydraulic fracking technology enable oil firms to drill themselves out of the prospects of finite fossil reserves. British, German and US citizens revolt against plastering rural landscapes with wind turbines. Following the construction of major oil pipelines, traffic and transport connections are planned to link Central to South and East Asia. During the social media-fueled Arab spring, Al Jazeera's English voice was available in over 260 million households across 130 different countries. Digital warehouses worldwide use roughly 30 billion watts of electricity equivalent to the electric output of 30 nuclear power plants. Through Facebook 955 million active users have been linked globally in a time span of less than a decade. Data center traffic now totals 3,3 zettabyte and up to 35 Million netizens follow individual accounts on Sina Weibo or Twitter. US and British intelligence agencies track every single mobile phone in real time, as they record the worldwide data streams. Internet surfing and communication seems to change brain structures, national identities, and the struggle for political freedom. The stability of virtual data processing and highly precise time standardization is of utmost concern, vital to banking, communications, commerce, traffic, energy, defense, media, and health systems. The anticipation of errors in computer systems, such as the assumed millennium bug, leads governments and enterprises to spend billions on digital infrastructures, while the interplay of corruption and oversight failure enables a global shadow industry to move approximately 50 million tons of electronic waste and illegally discard the equipment in the developing world per year. Myriads of microscopic chemical particles and radioactive substances have traveled as products, waste and emissions to the most remote corners of the planet. The toxic imprints of techno-scientific civilization reach anywhere from the highest mountains and the polar regions to subterranean and deep-sea areas and the cells of human bodies. As the European commission fights the interception of private data by Google, Apple's* *map service reveals secret Taiwanese missile silos and Microsoft secretly provides the NSA direct access to costumer email accounts and chat data. The US space command wants to conquer to the Lagrange points in outer space, US congressmen want to establish a National Historic Park at the moon, and China and India prepare for indigenous missions into outer space while private space companies invest into a multi-planetary human civilization.*

This book attempts to theorize technological innovations as an integral part of global politics. It is motivated by two observations. First, as the above canvas indicates, ours is a "technological civilization" (Dant 2005); a reality permeated by myriads of technologies and technical systems. Ever since a series of scientific and technological revolutions set in, the political, the social and the international are thoroughly interweaved, mediated, and made of machines and complex artifacts (Mumford 1966, Adas 1990, Woolgar 1991, Latour 1987). Given the related socio-technical transformations, any international or transnational issue likely entails technological aspects. The second observation, which stands in a certain tension with the first, concerns the way in which scholarship on international relations deals with the pervasiveness of science and technology. Most international relations (IR) theories are surprisingly indifferent to the emergence and consequences of new technologies. While some students of international relations have insisted in taking notice, the "classical" schools and canonical theories in IR regard technology as an "esoteric" issue at best—as Charles Weiss (2005, p. 309) points out. For instance, few IR scholars have ventured to make sense of the contradictory ways in which technologies actually sustain a highly interconnected and interdependent human life, and yet, at the same time, threaten the survival of human civilization (Luke 2003, Linklater 2009, Deudney 2014). If one acknowledges that everything from mundane private life and foreign policy to the macro-level of world politics is mediated by technologies (Frosch et al. 1999), then it is curious to see how much this reality is left under-researched and under-theorized by scholarship on international relations.

It seems that the inquiry into technological innovations does not capture something fundamental about international politics and therefore has not become a distinct research field (Mayer et al 2014a).[1] The fact that global politics unfold in a fully interconnected industrial civilization embedded in dynamic technological transformations is almost entirely absent from textbooks and introductions to IR. There are no paradigmatic debates concerned with science and technology as such. A specific subfield and dedicated journals have not been stablished. Though certain technologies feature in scholarly debates about sovereignty, power or governance, they are neither treated as coherent empirical subject matter, nor as theoretical puzzles in their own rights (Deibert 1997, Eriksson and Giacomello 2006, Singh 2008, Herrera 2003, Fritsch 2011). Efforts to develop theoretical frameworks remained limited and without impact on the broader theoretical debates within IR. Notwithstanding the pervasive public debates over information-, gene-, bio-, and nano-technologies and the growing political attention towards emerging technological opportunities and risks, International Relations (henceforth IR) scholarship has remained by and large remarkably silent about technological innovations.

This book proposes that technological innovations are a significant 'blind spot' that needs to be examined. This omission can be utilized productively in two ways. *First*, probing into innovation as a form of technological change questions IR's systematic biases. As the growing 'neo-materialist' literature points out from different angles, IR suffers from a fixation on social, subjective and ideational factors.[2] Tying into this literature, I suggest reconstructing the theoretical framework of IR by interrogating the omission of technological innovation as a subject for research and theorizing. How could IR theories oversee the monumental landscape that has been created by continuous technological innovations? Why do technologies not feature more prominently within the discipline of IR? Chapters 4 and 5 advance the claim that traditional theorizing in IR, despite its immense richness and diversity, shares a common meta-theoretical framework. Thus revisiting the explicit and implicit assumptions of existing theoretical approaches

[1] Hypothetically, we could assume that if the literature on technological innovations relates to something fundamental about international politics—as for instance the research about regimes, democratic peace, or international organizations—it would speak back to the mainstream theoretical debates. Yet, thus far, is has not occurred to many scholars to conceive of a domain of "global techno-politics" that requires a distinct mode of inquiry and is different from other fields at the conceptual level (see Mayer et al. 2014a).

[2] See e.g. Cole (2013), Barry (2013a), Connolly (2013), Squire (2014) Schouten (2013), Acuto (2014), Grove (2016), Burke et al. (2016).

about technology helps reveal the "lightness" of IR scholarship. The "Cartesian complex" (see Chapter 4) reinforces a perspective such that there are no material artifacts; or, such that the pervasive presence of technologies would remain without relevance for our theorizing, conceptualizing and examining world politics. As this book will demonstrate, the paradoxical phenomena induced by technological innovations, therefore, usually overstretch the common binaries, instrumentalist notions, and state-centric analyses.

Against this backdrop, the *second* step is to develop a theoretical model that makes sense of the global politics of technological innovations. Attempts to theorize technological innovation, while calling into question essential categories, meta-theoretical distinctions, and ontological foundations shared by theoretical "mainstream" approaches, do not merely amount to adding yet another IR approach. How can we accommodate to and conceptualize the pervasiveness and consequences of technological innovations for global politics? How to bring back the "missing mass"? To begin this effort, this introduction discusses the different academic and political concerns with technological innovations (1.1), and how they tend to lead to paradoxical theoretical puzzles (1.2). Theorizing innovations requires more than just adapting existing concepts. A good starting point is to cope with the diversity of technological transformations that continues to change politics and society (1.3). In this line, the last section of this introduction lays out the overall structure of the book (1.4). Conceptually, the book develops three models of "creative destruction": assembling, reassembling, and disassembling. Based on the notion of assemblages, this theoretical framework elaborates on the link between two ideas that study the juxtaposition of transformation and political order: the "maelstrom of modern life" of ongoing technological progress and renewal, as Berman (2010, p. 16) put it on the one hand, and the idea of "coproduction" (Jasanoff 2004a), that is, social and political order arising at the nexus of epistemic, cultural and material realities on the other.

1.1 Technological innovations as political and academic concerns

Technological innovations attract enormous attention in political circles. The idea of "the race to the top" permeates policy discourses all around the world. Political elites understand economic competitiveness and investments into research and development as closely interrelated trends. Technological innovation is univocally seen as paramount for progress, wealth, and power, at least in the OECD countries and the newly industrializing economies (Slaughter and Rhoades 1996, Barry and Slater 2002). The outlook of Graham R. Mitchell, former United States' Assistant Secretary of Commerce for Technology Policy, is indicative for the widely shared positive expectations: "Time after time, in epoch after epoch and country after country, technological advance has produced higher wages and living standards, not mass unemployment. This is exactly what we expect to happen in the 21st century." (Mitchell 1999, p. 214) Likewise, politicians and academics in emerging economies are concerned with the pitfalls of technological backwardness and how to overcome it with policies for education, science, research and development. India's government has proclaimed that it will become a knowledge superpower by 2050. China's leaders are pushing hard for homegrown innovations (Below et al. 2012, Segal 2010) while Chinese enterprises now apply for more patents than companies in any other country. As India, China, Brazil and South Africa pursue explicit "catch up" strategies, transnational companies are fiercely competing for the latest patents, copyrights, and trademarks and for the brightest engineers, and researchers within these countries (Frietsch and Schueller 2010, Parayil and D´Costa 2009).

States and markets became intimately entangled in the race for technological innovations. Whatever one prefers theoretically or normatively, state-company collaborations in Japan, South Korea, Singapore, Israel, or Taiwan were quite successful (Castells and Hall 1994, Breznitz 2007). This is not only due to subsidies, trade regulations, market barriers or other hidden forms of support and subsidies that blur the state-market distinction. National policies also became increasingly crucial for innovations through the networked activities of patent offices (Drahos 2010). Although these practices have economic disadvantages for developing economies, they help create a landscape of emerging multinational corporations, increasingly sprinkled with firms that are intimately intertwined with national bureaucracies, the military or party interests. ZTE, Suzlon, HTC, Sinopec, Petrobas, Huawei, Samsung, Tencent, Gazprom and others eagerly compete with their Western peers by extending their market shares by means of patent lawsuits, lobbying, and, of course, increased research and development investments (Taplin and Nowak 2010, Yu 2012, Mahlich and Pascha 2012). Rhetorical references to neoliberal ideology notwithstanding, the conceptual separation between markets, companies and states with respect to innovational dynamics is much less clear than textbooks would suggest.

To govern technological innovations through centralized research funding and tailored policies and administrative regulations, however, is a fairly recent occurrence. It took governments in Europe and North America until the Second World War to seriously consider comprehensive science and technology policies for the first time (see Chapter 2). Today's governments and armed forces have, in contrast, engineered close and often seamless collaborative networks between universities, research labs, and enterprises—redefining the role and functions of universities first and foremost as birthplaces of commercially relevant technological innovations (Robertson 2005). Mainly as a byproduct of the Cold War, national policies came to systematically intertwine scientific research in various with both civilian and military technology, as well as commercial and public activities in order to control and to fuel technological innovations especially in nuclear physics, nuclear energy, space technology, and computer science (Dickson 1988, Krige 2006). The same blurring of categorical binaries such as state and market or technology and society, that are constitutive of many social theories, is even more characteristic of the ongoing informational revolution driven by digitalization and datafication (Castells 2000, Nowotny, Scott, and Gibbons 2001, Cukier and Mayer-Schoenberger 2013). In short, innovations are processes of hybridization in which scientific, commercial, military, and bureaucratic contexts became intermingled.

Besides profound strategic and military interest in cutting-edge weapon technologies, additional factors account for the current acknowledgement of the centrality of technology. Shifts in intellectual history, in particular novel economic theories, became instrumental for attributing social and economic changes to technological innovations. New research fields such as *New Growth Economics* and *Evolutionary Economics* provided a strong scientific backbone to the perceived relevance of science and technology (Machlup 1962, Griffin 1974, Freeman 1974, 1987, Abernathy and Clark 1985). Robert Solow, who won the Nobel Prize in 1987, lamented that "computers are everywhere in the economy except in the productivity statistics" (cited after de la Mothe 2004, p. 524). The strange disconnect between technologies and economic theory was coined "Solow Paradox". Responding to these observations, an emerging economic paradigm characteristically placed technological innovations at the center of economy and society (de la Mothe 2004, pp. 524-525, Russell 1997). Technology was thereby elevated to a critical driving force behind growth, wealth inequalities, trade relations, and boom and bust cycles (OECD 1996, Freeman 2007). Slowly but steadily, evolutionary economics is making inroads into mainstream economics.[3] For instance, in recognition of his non-perfect competition model that turns economic theory from a static affair into an evolutionary process (Romer 1990), Paul Romer was among the 2011 Nobel Prize candidates.

Sociologists similarly began considering the role of knowledge for production processes, stressing the dematerialization of economic activities (Bell 1973). Sociological and economic ideas, emphasizing the role of technological revolutions and evolving know-how, underpinned new metaphors such as the "knowledge-economy" and the "network society" (Stehr and Moldaschl 2010, Peters 2004). Progressive commercially driven innovations were deemed to have led to massive shift in the organization of production chains and trade networks (Willke 1998, Stehr 2001). In addition, the burgeoning field of innovation studies produced a treasure of comparative analysis on innovational competitiveness and historically evolving institutions governing, and at the same time affected by, technological change.[4] These academic discourses tend to render the achievement of technological innovations into a political imperative as "human capital" and novel technologies are by now seen, philosophically and practically, as the main driving forces of economic growth. Consequently, one default policy advice is to create "national innovation systems", by consistently fostering education, research and development, in order to harness the economic fruits of knowledge economies (Fagerberg 1987, Dosi, Freeman, Nelson, Silverberg, and Soete 1988, Freeman 1995, Lundvall 1992/2010).

The contemporary emphasis on knowledge and technology therefore is as much a

[3] Schumpeter's idea of "creative destruction" is perhaps its single-most important intellectual source (see Balabkins 2003, Diamond 2006, Freeman 2007).

[4] See Fagerberg and Verspagen (2009) for a comprehensive overview how the field has developed during the last three decades.

description of emerging patterns, as it resembles the enactment of related theories and perceptions (Godin 2002, 2006, Robertson 2008). This generic mix of prescriptive council and descriptive analysis is characteristic, too, of international organizations including the OECD, which reinforces the same message by means of an apparatus of rankings, statistical studies, and manuals to comparatively measure innovation (Godin 2002). In turn, a certain circularity of knowledge arises because innovation policies and expertise about innovation processes are increasingly mutually constitutive.

Scholars in the field of international relations instead mainly link technological innovation to the study of security and power. Realist scholars in particular have seen changes in material circumstances as critical for national security and peace (Herz 1959, Gilpin 1981, see also Deudney 2014). "The value of science and technology has enormously increased in the calculus of national power", noted Hans J. Morgenthau, because military power became primarily measured by "scientific breakthroughs and technological innovations" (1964, p. 1393). Consequently, realist theories assume that inventions in weapons technology and shifting technological gaps can lead to territorial conquests and, ultimately, may unleash hegemonic wars (Kennedy 1987, Gilpin 1981). The unpredictable progress of technical inventions compels states to be permanently concerned, anticipating and adapting to the moving ground of sudden innovations in the hand of rivals or enemies. This explains why, according to a realist perspective that assumes Darwinian competition for survival as the inescapable mode of existence of nation states, governments sacrifice a considerable share of their budgets to remain, if even symbolically, ahead of their rivals or, conversely, to catch up with leading powers (Buzan 1987). Political elites and foreign policy pundits have stressed the importance of investing in the "technological edge" in a recurrent pattern (Paarlberg 2004).

From the perspective of International Political Economy (IPE), Susan Strange similarly argued that modern state power is mainly based on technological leadership (Russell 1997b). Her structural approach replaces the primacy of security concerns with the premise that "global knowledge structure" has become the central arena of international competition:

"The competition between states is becoming a competition for leadership in the

> knowledge structure. The competition used to be for territory, when land and natural resources were the major factor in the production of wealth and therefore the acquisition of power for the state. Then the competition was for industrial 'sinews of war' provided by the manufacture of steel, and later for chemicals, and petroleum and electric power. Today, the competition is for a place at the leading edge (as the jargon has it) of advance technology. This is the means both to military superiority and to economic prosperity, invulnerability and dominance." (Strange 1988, p. 136)

Since the 1980s, observers have predicted global economic shifts and stiffer technological competition due to Asia's rise. While Japan initially appeared destined to overtake the global leadership position, it is the huge number of graduates from Chinese and Indian universities that are now seen as indicative of declining European and US innovativeness.[5] Additional indicators including patent applications, research funding, publications, or high-tech exports suggest that India, China, and other emerging economies are eagerly catching up with the OECD world (Altenburg, Schmitz, and Stamm 2008, Royal Society 2011, Mahmood and Singh 2003).

> "A central finding of economics over the past fifty years has been that technological advancement is critical to long-term economic growth (…) we predict that one of the twenty-first-century's biggest transitions will occur when both China and India begin to make dramatic contributions to global science and technology and thereby dramatic contributions to the welfare of the world. When this happens, the structure of the world economy will change in new and promising ways." (Sachs and McArthur 2002, p. 183)

Sachs and McArthur have not ventured to explain precisely which kind of "new and promising" changes they expect though. Their vagueness results from our limited comprehension of these phenomena, since the alleged shifts are less clearly measurable than one would think. The very nature of technological transformation renders aggregate indices and rankings unreliable. Systematic statistical data can be easily misleading (see Archibugi and Coco 2005, Castellacci and Archibugi 2008, Leydesdorff and Zhou 2005), thus mirroring what Rosenau has noted in *Turbulence in World Politics*: "uncertainty is a

[5] Peters (2004) traces the awareness of technological competition back to the 1980s. Particularly, the issue of technological backwardness as compared to Japan became a serious concern in the United States (Singh 2002). Of course, this sort of concerns is not unprecedented; see the second chapter for a historical overview.

prime characteristic of turbulent politics" (1990, p. 8). On balance, it is fair to say that our knowledge of whether the OECD countries can still be regarded as the leading "knowledge powers" is incoherent conflictive.

Consider China's alleged rise for the problem of conceptualizing and measuring shifts in knowledge power and technological leadership. Analysts stressing the significance of technological factors (which actually constitute a minority) advance claims that, apparently, are highly contradictory. China has almost eliminated illiteracy in less than one hundred years, producing hundreds of millions of educated people and dozens of millions of excellent engineers, researchers, and scientists. But the astonishing numbers often reflect more quantity than actual quality of graduates (Gereffi, Wadhwa, Rissing and Ong 2008), thus leaving one puzzled about the true extent of Chinese capacities. So, is China *overtaking* in technological leadership—or is it just *approaching* the circle of first-tier innovators, or rather is it actually *lagging behind*—because it is trapped in a mode of intensive production with low innovation activities?[6] The important point that we have to recognize is not the striking discrepancy of these claims *per se*. Truly intriguing is that the underlying question makes little sense in the first place. Because the Chinese case resembles a combination of the two big puzzles described above, it shows that we are at least empirically unable to conceive, at a general level, in which ways technological innovations have led to increases or decreases of "national power". It is therefore not by accident that an eminent expert such as Adam Segal (2008, p. 423) remarks that he is "perplexed about the actual status of American, Chinese, and Indian technological capabilities." The paradoxes of China's rise hence cause realist framings and instrumental understandings of technology to collapse:

> "There is evidence to support two different views: that China and India will soon emerge as technological superpowers, and its opposite, that they will continue struggling to overcome major challenges. As a result, both policy makers and engaged citizens lack a clear sense of where their country stands relative to its competitors and what policies should be implemented in response." (Segal 2008, p. 423)

[6] These contradictory claims are made in various studies and reports (see Segal 2003, Preeg 2005, Wang 2006, Adams, King and Ma 2009, Sainsbury of Turville 2007, Simon and Cao 2009, Segal 2010, Breznitz and Murphree 2011, Lampton 2008, Wadhwa 2010, Mayer 2012b).

But even if the precise ranking of national economies remains unclear, the paramount importance of technological innovation is seen as common sense. Technological advances, the global skill revolution, and economic dynamism appear strongly interrelated and mutually reinforcing (OECD 1996, Archibugi and Michie 1997, Dicken 2007).

The intimate relationship between innovation and security is discernible from the political discourse in Europe and North America, characteristically rife with rhetoric reminiscent of the Cold War. Many observers respond to the emerging economies' eagerness to "climb the ladder" with genuine fear (Segal 2004). Surely, the restless lobbying effort focused on selling high-tech arms such as stealth fighters and frigates, drones and robotic platforms reinforces, if not often creates, popular threat perceptions concerning the catch up of countries in the global East and South in terms of innovation and research capacities.[7] Politicians, often indirectly, point towards security ramifications of commercial technology races. Alarmist overtones are omnipresent as exemplified by this British expert commission's dramatic statement: "We can be one of the winners in 'the race to the top', but only if we run fast." (Sainsbury of Turville 2007, p. 8) In his 2011 State of the Union Address, US President Obama even embraced the renewal of the "Sputnik moment":

> "Half a century ago, when the Soviets beat us into space with the launch of a satellite called Sputnik, we had no idea how we would beat them to the moon. The science wasn't even there yet. NASA didn't exist. But after investing in better research and education, we didn't just surpass the Soviets; we unleashed a wave of innovation that created new industries and millions of new jobs. This is our generation's Sputnik moment. Two years ago, I said that we needed to reach a level of research and development we haven't seen since the height of the Space Race." (White House 2011)

This rallying call indicates the seamless intermingling of security and economic considerations typical of the contemporary US defense imagination and digital surveillance practices.

[7] These threat perceptions are in no small part resulting from public relation and entertainment activities of the US military-industrial-media complex (see Der Derian 2009). Lockheed Martin, Boeing, and thousands of smaller companies have a strong interest that the Pentagon, the Congress, and the White House relentlessly pursue global "full-spectrum" dominance.

This cursory overview has made clear that technological innovations obviously are critical for international affairs. However, the work of IR scholars already suggests that there are non-trivial obstacles to elaborating the theoretical puzzles arising from our subject matter. Information networks are not merely instrumental in expanding national "capacities". They rather "reconfigure, constitute, or reconstitute identities, interests, and institutions" (Singh 2002, p. 13). The ubiquity of information technologies rather implies a meta-power that is different from the coercive forms of power usually assumed in IR (JP Singh 2013). In addition, the blurring of common boundaries such as those between 'states' and 'markets' or between 'economy' and 'security' as well as the misfit between path-dependency and instrumentalist treatments of technology considerably complicate matters. Numerous studies of innovation demonstrate the long-term effects of technologies that challenge instrumentalist assumptions. As state agencies attempt to command or steer the occurrence of novel weapons, infrastructures and communication systems, they have to cope with macrostructures and cumulated by preexisting technical systems as well as unevenly distributed ownership of expertise and practical knowledge. The next section, then, further systematizes the conceptual obstacles to theorize technological innovations.

1.2 Paradox puzzles for IR and the destabilization of concepts

Insights from from innovation studies and science and technology studies (STS) elucidate how entire building-blocs of IR theories run into unsolvable paradoxes because of the complex consequences of technologies. The aforementioned concerns can be systematically organized around three topics: "the state", "power-politics", and "rationality". What are the limits of conceptualizing technologies as instruments of states, serving the pursuit of national interests? How do the unintended and unruly aspects of technologies affect our understanding of the "inter-national" and presumptions of human agency? The crucial problem, I argue, lies at the level of meta-theoretical presumptions that render theoretical puzzles in IR intelligible. To phrase it differently, the foundational framework underpinning most approaches to IR is incapable of taking account of the significance of the non-linear transformations tied to technological innovations.

First, the complexity of technology and related forms of knowledge makes it difficult to pinpoint the conceptual place of the "state". For one thing, there is the problematic attribution of agential effects: Governments can promote innovation-friendly institutions, technical standards, and regulations for IPR that profoundly impact processes of knowledge creation (Juma et al. 2001, Fagerberg and Srholec 2008), as the enormous success of the "Asian Tigers" exemplifies (Evers, Menkhoff and Wah 2010, Hornidge 2008). Yet innovations cannot simply be called forth by means of top-down regulations or incentives as will be argued below. For another, the preeminent role of private companies remains difficult to account for: IPE has for long shown that technological changes usually tend to favor large companies and private actors at the expense of states. This is because the latter are either incapable of regulating newly emerged activities or constantly lag behind in their efforts to do so (Strange 1996, Russell 1997b, Gill and Law 1989).[8] Internet corporations, recently, have initiated a powerful wave of privatization of authority (Deibert 2013). IR studies therefore point to a diffusion of power as privatized information-flows potentially undermine national security, sovereignty, and state capacity (Rosenau and Singh 2002, Aronson 2002, Nye 2011).

Second, the problem of the longue durée: effective educational policies can produce more and better-qualified human capital over several generations. To establish a full-fledged educational system including world-class universities may require decades or centuries; a period which seems, however, well beyond the horizon of reasonable foresight and state-led planning. "Large technical systems" are another long-term force that develops inherent "momentum" and "styles" which are stable and can become, at times, a constraining force for all involved actors, including governments (Hughes 1983). Given such long-term trends or trajectories, a short-term view on the position of the state inevitably leads conceptual difficulties.

Third, it has been pointed out in studies of global governance, that the

[8] Archibugi's (2010) conclusion that the current IPR are in the interest of a small number of multinational enterprises, yet not necessarily conducive for the national economies as a whole, corresponds with earlier assertions that the accelerating development of technologies is a "prime cause of the shift in the state-market balance of power." (Strange 1996, p. 7) The balance of the global knowledge structures appears to increasingly tilt towards the big corporations at the expense of states. For others patents and copyrights are unnecessary for innovation to happen at all (see Boldrin and Levine 2008).

reconciliation of the reality of networked governance and homogenous notions of the state (or international organizations) is impossible (Slaughter 2004). Information technologies, satellites, containers, or social media have enabled large networks, connecting a plethora of non-state actors across the globe and different scales. Technologically mediated governance typically invests various actors with considerable power over and authority for governance, regulation, and standardization (Litfin 1999, Nye 2004, Murphy and Yates 2009). Rosenau's response to this sort of diagnosis was theoretical bifurcation. As the "combination of dynamic technologies and global decentralization" has given rise to a "postinternational" situation, IR has to cope with two coexisting worlds—a world of sovereignty-bound and a world of sovereignty-free actors—in which states have become "*both indispensible and inadequate*." (Rosenau 1990, pp. 247-249) To put it differently, simplified assumptions about the "state" are outdated.

> Historically, power was embedded in organizations and institutions, organized around a hierarchy of centres. Networks dissolve centres, they disorganize hierarchy, and make materially impossible the exercise of hierarchical power without processing instructions in the network, according to the network's morphological rules. Thus, contemporary information networks of capital, production, trade, science, communication, human rights, and crime, bypass the nation-state, which, by and large, has stopped being a sovereign entity (Castells 2000, p. 19).

Digital communication networks allow for swift and unhindered flows of information, expertise, and scientific knowledge while mobile communication technologies empower entrepreneurs worldwide, leveling the playing field for companies from developing countries (Castells et al. 2007, Friedman 2009). "The state", according to Manual Castells, "reacts to its bypassing by information networks, by transforming itself into a network state. In so doing, its former centres fade away as centres becoming nodes of power-sharing, and forming institutional networks." (2000, p. 19). It has been demonstrated consistently that state apparatuses and sovereign practices become disaggregated as governments have entirely reorganized their decision-making procedures (Slaughter 2004, Grewal 2008).

These empirical insights have hardly been channeled back into theorizing in order to unpack the 'state'. The main research focus of IR scholarship on information technologies remains rather restricted: the primary concern revolves around the question of whether the recent rise of information technologies leads to a demise of the territorial nation state.[9] On the other end of the spectrum, notions of "network" and "assemblage" have become powerful metaphors in the research of sociologists and STS scholars who focused on processes in which prevailing forms of social organization, such as nation-states and national economies, are increasingly substituted or transformed (Castells 2007, 2010, Passoth and Rowland 2010). The question of how the state can be lodged conceptually within puzzles arising from networks, digital revolutions and technological reorganization remains unanswered. It is in this sense, that Rosenau's distinction between "postinternational" and "international" domains is still valuable. For it demonstrates a sensibility for complexity (or "turbulence" in Rosenau's terms) and offers a way to articulate the state as an actor, whereas mainstream IR has a long way to embrace the *variety and the scope* of diverse technological transformations that change fundamental parameters of human life, politics, and statehood.

Besides destabilizing unitary actor assumptions, the analysis of power is another "casualty" when we take technological innovations seriously. Paradoxes emerge at the theoretical level as the following stylized puzzles about the interplay between power-seeking strategies and technological change illustrate.

Innovativeness and paradoxes of late development: While the diffusion of technologies and the access to technical know-how is thought to close the gap between wealthy post-industrial and emerging developing economies—many hope that thereby the medical treatment and the education possibilities of the planet's poor populations will be quickly improved as well (Juma et al. 2001)—emerging states such as India, Brazil and China aim at establishing strong national innovation systems. This agenda, governments believe, will foster indigenous innovation capacities and put companies into a better market position while reducing the increasing dependence on foreign technologies, if not rendering "their" economies technologically more autonomous. On the other hand, these governments resort to neo-mercantilist policies, parts of which are

[9] See e.g. Krasner (1991), Keohane and Nye (1998), Eriksson and Giacomello (2006), Hanson (2008) and Mueller (2010).

especially weak intellectual property regimes, in order to foster infant industries and copy foreign designs. Yet the very weakness of IP regulations hinders the emergence of strong indigenous innovation abilities exactly because companies lack the incentives and the institutional framework to innovate. In addition, they are hardly able to hedge against the huge financial risks involved with innovational activities (cf. Breznitz and Murphree 2011). Paradoxically, emerging economies as a whole may benefit from counterfeiting and cheap imitated goods whereas entrepreneurs and companies, by engaging in the lower strata of global production chains, are prohibited from becoming truly innovative (e.g. Wang 2006). Hence, emerging economies risk falling into the "middle income trap". They decisively fall short of developing innovation-based competitive strength in rapidly advancing world markets—that has been, as it were, the original goal of governments.

Innovation, diffusion and paradoxes of dominance: For strategic reasons and pressured by private enterprises, powerful states try to prevent the proliferation of critical technologies. At the same time, governments lobby for the implementation of a strict global intellectual property regime so that companies can fully exploit their monopolies on new technologies and their countries' technological leadership can be sustained (see Gilpin 1981). Yet these goals are sometimes contradictory. Introducing stronger and stricter intellectual property regulations globally has given rise to "patent warming" and to the multiplication of "patent dwarfs", hampering innovation processes rather than supporting their acceleration (Weißbach 2010). Furthermore, to maintain innovative capabilities requires absorption and adoption abilities. The idea of autarky denies the reality of global division of labor imminent to transnational productions networks. The latter automatically spur the worldwide diffusion of know-how and technologies. As a consequence, this means in on the one hand complex interdependencies between firms or their subsidiaries across national borders and on the other hand increasing concerns by firms (and politicians) that do not want to lose technologies. Governments also fear the proliferation of dual-use technologies to enemies or rivals. Militaries are facing a similar dilemma: they are major drivers and funders for R&D yet faster innovation cycles render their own weapon systems obsolete quicker. In addition, they are threatened by attacks using dual-use technologies. At the same time, however, their combat and communication systems increasingly depend on foreign innovations because of widespread practices of outsourcing within global production networks. Here again, we are full circle, since the attempts to preserve dominance through preventing homegrown technologies from diffusing must be undermined by companies and the military eventually.

If we accept for the moment a highly simplified treatment and analyze technological innovations through the lens of classical power politics, then the results are confusing. Logical plausibility and empirical evidence suffices to undermine the premise implicit to many IR theories that governments exert command, control, and hence, predictive power over evolving technologies (Singh 2002, p. 6ff). It leads us not only to doubt the merits of instrumentalist narratives, including the "race for technology", but also to scrutinize the presumptions underpinning instrumentalism: To assume humans are generally capable of controlling emerging technologies (and thus easily supportive for specific policy goals) is naïve at best and ignorant at least.

The history of technological innovations is full of examples that elude both instrumentalist understandings of technology and simple rational actor assumptions despite politicians, scientists, or generals portrayal of new technologies as mere tools (Woolgar 1991, Winston 2007). Even tiny technological artifacts or small systems can have far-reaching and unforeseen consequences as they are interconnected to the larger world through myriads of, usually hidden, entanglements and logics (Furlong 2011). A superficial look at the surprising outcomes of recent technological innovations is illustrative: scientific applications, initially developed for the military, translate into massive changes of commercial and political collective activities (e.g. Internet and Web 2.0); large-scale computer modeling, initially funded to study Cold War strategies, enables and legitimizes the peaceful vision of alternative global identities and transnational political agendas (e.g. Club of Rome report, global warming); public infrastructures for civil transport empower marginal actors to pick a fight against a superpower (e.g. Al Qaida); advances in computer technology, robotics and automation that have improved macro-economic productivity also, for the first time, lead to a worrying decoupling of productivity and job growth and contradictory economic wisdom (Brynjolfsson and McAfee 2011); the National Security Agency with a estimated staff of 30.000 can monitor and access data streams from computers, mobile phones and cloud services in real time and on a global basis, but a single person was able to leak information shattering US foreign policy for years.

Numerous additional examples make the same point: emerging artifacts and technical systems are always open-ended, evolving alongside new practices and expertise. Inevitably, they have *unexpected* and *unintended* consequences (Wynne 1988, Tenner 2004, see also Winner 1977). The unaccountable elements of technologies have not just both social and technical origins. They rather arise though the coupling and interplay of political, cultural, technical, and ecological factors. Charles Perrow (1984), for instance, stressed the immensely increased potential for devastating disasters as a consequence of proliferating high-risk technologies with a generic degree of "interactive complexity". Global catastrophes such the nuclear meltdown in Fukushima, Japan, illustrate the fragile institutional structures, biased organizational cultures, and selective expertise Perrow examined. Paul Virilio proposed that a specific sort of accident and engineering failure would be inherent to every new technology (see Crogan 2000). The daily experience of lurking dangers and harm from technological innovations, ranging from localized to planetary scales, reflects life within a "global risk society" (Beck 2012). STS scholars explore the public controversies, which characteristically accompany the emergence new artifacts and systems, chemical products or genetic test trials (Nelkin 1979, Jasanoff 2011). Their work on sociotechnical and political constructions of technologies similarly refute instrumentalist frameworks, showing in addition that technical systems are not determinants of individual behavior and social institutions but rather subject to social, cultural and institutional designs (MacKenzie 1990, Pinch 1996, Bijker 1995). The empirical phenomenon of unintended consequences, to phrase it differently, is thus not in any way suggestive of technological determinism, the polar opposite of instrumentalism.

The ultimate riposte against instrumentalist assumptions is that we have our most serious concerns with, more often than not, the lack of control, the breakdown of oversight, and unstable epistemologies underlying public reasoning and legal and political decision-making. Technological innovations are not easily reconcilable with conventional approaches that treat nation states as homogeneous actors. Neither do novel technologies simply function as resources for, or capabilities of, state power. It can be concluded that maintaining a rationalist and state-centric vocabulary in IR must inevitably produce theoretical paradoxes. Even if we frame technologies so as to fit into an instrumentalist framework, we are confronted with conflicting evidence in defiance of theoretical explanations—a troubling experience that many scholars who council policy makers share. It is therefore not surprising that the sporadic engagement with technologies stands at odds with standard IR theories and conceptual notions. Theoretical schools and paradigmatic debates have either eschewed technologies as a subject matter or simply taken an instrumentalist stance, defining technologies as mute sources of state power (see Chapter 4 for a detailed discussion). Presented with such impenetrable obstacles, I suggest taking a step back: why are the politics of technological innovations so hard to grasp? The inability to capture technological transformations in their diversity and scope as well as the aforementioned puzzling theoretical paradoxes require us to turn our attention, for a while, from theorizing to description. Perhaps we need to choose an entirely different methodological starting point and a different understanding of technology that encompass the complexity of the concept. The first question, then, is how to comprehend and collect empirical data about technological innovations anew.

1.3 Human life transformed

The simplest option to cope with the diversity of technological innovations is to fabricate a list of items as I did at the beginning of this introduction. Museums, encyclopedias, and databases contain huge quantities of artifacts and do not suffer from "lightness" (see Ferraris 2013). Catalogues and cataloguing are not trivial as knowledge apparatus. Diderot's and d'Alambert's monumental *Encyclopedia* reminds one that the work of collecting, filing, and forging taxonomies remains central for comprehending the multiplicity of reality (Creech 1982). Today, in the age of "big data", such formations of knowledge are more than ever key to practices in business, science, and governance, though few people suggest a single universal "map" akin to what Diderot had in mind.[10] As such, lists, charts, and catalogues are indispensable for recognizing the sheer

[10] Most databases are sectional, organized on the basis of semiotic categories, encompassing classifications of crops, germs, plants, cells, genetic material, languages, personal information, web content, images, credit accounts, traffic flows, the human genome, weather data, video footage, indigenous knowledge, patents, and so on.

magnitude, vastness, and pervasiveness of machines, tools, infrastructures, systems, components and devices that have become integral and unquestioned parts of our lives.

Type of transformation	*Scientific revolutions*	*Military revolutions*	*Controver-sies about technology*	*Converging trends through technology clusters*	*Enclosures*	*Emerging new "actors"*
Example of technologies and processes	Quantum science System theory	Nuclear weapons Drones Cyber war	Military robots Chemical weapons	Acceleration Datafication Hybridization	Commodifi-cation of emissions Commodific ation of deep sea materials	Engineers, Hackers Simulation models Cyborgs

TABLE 1.1 INDICATORS OF GLOBAL TECHNOLOGICAL TRANSFORMATIONS ©AUTHOR

An alternative option to describe technological transformations is to outline overarching trends and global evolutionary processes related to emerging clusters of technologies (Russel 1997). Table 1.1 offers a set of indicators and examples for the transformative effects of technological innovations. Archeologist Marcia-Anne Dobres understands technology as "an ongoing and unfinished process through which people, society and things weave (…) the meaningful conditions of everyday life" (2000, p. 4). New technologies inevitably have transformative aspects and unexpected ramifications. What is at stake lies in the fluid and ambiguous character of technology itself. Although technological innovations often build on prior existing artifacts and practices, the above mentioned processes are nonlinear and cannot be easily understood (Hughes 1991, Moldaschl 2010). Moreover, there is no single driving force or master variable; neither can a single causal factor explain them. On the other hand, artifacts or systems such as the Internet do not simply determine collective interactions or political institutions. "Most historians", writes Thomas Hughes "consider a descriptive narrative that ignores the interacting technical, economic, political, and social components of technological change reductionist and distorting. New modes of research and presentation take the technological, or the sociotechnical, system rather than individual artifacts as the unit of study. Deterministic dynamos have given way to seamless-web systems." (Hughes 1991, p.22) Theorists from diverse research fields and disciplines have, observing the emergence of technology clusters, conceptualized larger trends with variegated effects on all aspects of human civilization including automatization, urbanization, time-space compression, electrification, commodification, digitalization, cyborgization, miniaturization, and datafication.[11]

In *The World is Flat*, Thomas L. Friedman eloquently lays out the transformative effects of a set of interacting recent technological innovations. In what is a sweeping Schumpeterian account of creative destruction, Friedman explains that the convergence of technologies (that he coins "the tens flatteners") with new business practices and the entrance of hundreds of millions of new entrepreneurs and corporations into world markets have produced a leveled playing field. Against his critics who point to the economic gaps between the traditional technologically leading countries and the emerging economies—not to mention other developing nations—Friedman argues that this "triple convergence" created a new economic reality that is barely captured by classical macro-economic indicators (Friedman 2009).

Acceleration is another example of the combination of overarching trends of convergence. The growth rates in computer storage capacity, the output of technical applications, and the increase in scientific knowledge follow (grounded in Moore's law) almost exponential trajectories (Kurzweil 2006). In the same vein, Philippe Morel's work on "Computationalism" stresses that computers are not just traditional labor saving machines but "an ever expending block of both abstract knowledge and concrete physical (nanoscale) constructions, calling for more and more discoveries" (Bava 2012). Probing into the accelerating pace of life, Hartmut Rosa among others assumes that the very stability of our social and economic systems came to depend on constant acceleration. Politics, here, are turned into a "speed game" (Rosa and Scheuerman 2009). Social acceleration and a growing interconnection of technological systems have immediate and far-reaching implications. The current use of drones illustrates insights raised earlier by James Der Derian (1990): in order to document multiple "revolutions in military affairs", the researcher has to come to terms with massive alterations in both the speed and the space of international politics (Beck and Crosthwaite 2007). Indeed, the technical shifts

[11] See e.g. Dicken (2007), Hughes (1983), Pfaffenberger (1992b), Lemonnier (1992), Kaplan (2004), Feenberg (1999), Jasanoff (2004b), Jasanoff et al. (1995), Kaplan (2004), Hughes and Pinch (1987), Hackett et al. (2008), Cutcliffe and Mitcham (2001), Smith and Marx (1994), Bell (2000), Killick (2004), Aronowitz, Martinson, and Menser (2006), Gray (1995), and Dobres (2010).

from the air-age, to the nuclear age, and now to the drone- and cyber-age have immensely changed the shape of offensive and defensive strategies. This understanding stresses fundamental historical re-articulations of warfare and security (Freedman 2003, Manjikian 2012, C. H. Gray 2004, Sanger 2012).

With the rise of the Internet, for instance, cyber security has suddenly become a highly dynamic issue of great power politics, national defense, and military strategy (Dunn Cavelty 2013, Lagerkvist 2010). At the same time, the proliferation and ubiquitous use of mobile devices and satellite based mapping services brought fourth, Benjamin H. Bratton suggests, the "unlikely compatibility" between Jihad and Google as in the case of the Mumbai bombings in November 2008 (Bratton 2009, p. 335). The creative application of technologies speaks to Manuel Delanda's (1991) analysis, which puts the changing logistics of circulation, resource supply, and governing are at the core of military strategy and practices of violence. In sum, the network- and information technologies-based military revolution leads to a "blurring of almost every geopolitical dimension" (Ek 2000, p. 862). Imagined once erroneously as a network for liberating communication and free virtual exchange,[12] the Internet is now dominated, in Ron Deibert's words, by "black code". An increasing criminalization and militarization of the Internet seems almost irresistible (Deibert 2013), while the blossoming industry of digital war games powerfully contributes to the idea of perpetual war fostering the normalization of a militarist culture (Power 2007).

Long before the advent of the Internet, electronic media technologies in the service of mass propaganda and public relations have fundamentally changed public opinion and (global) political discourses as extensively examined in the works of Marshall McLuhan (1989) and Noam Chomsky (2002). High-speed transmission of images afforded constant real-time news coverage, transforming global power projection and framing of war and public politics:

> "Aside from the familiar technological innovations already recounted, I believe that IT has given rise to a new digital media based on a *moving* image of the world. In both senses of

[12] At the same time, former Liberal Democrat leader Lord Ashdown warned that the employment of surveillance technologies is "out of control" – undermining the very ideas of privacy and civil liberties (Hopkins and Taylor 2013).

> the word, this multi-media is *e*-motive, a transient electronic affect conveyed at speed. At the emotional level, this means image-based sentiments of fear, hate, and empathy now dominant word-based discourses of ideas, interests, and power. At the electronic level, the speed of the transmission—with real-time currently the gold standard of media—matters as much as the content of the message. Paul Virilio, urban architect and social critic, has spent a lifetime demonstrating how this media-driven acceleration has produced what he calls an 'aesthetics of disappearance', in which the political subject, be it the accountable leader, participatory citizen, the deliberative process itself, is diminished and quickly engulfed by a growing 'infosphere'". (Der Derian 2003, p. 444)

Not only have all-encompassing simulation capacities and cyber networks added new domains within which international relations operate. The rapidly increasing influence of scientific expertise and experts on agenda-setting and decision-making also mirrors the transformative power of technologies (Haas 2004, Edwards 2006). Knowledge has been turned into a precious resource and tool for policy making both at the international and national level. In turn, the capacity to produce research results and simulations becomes important to the choices and influence of actors in international decision-making in all major policy fields (Sachs 1991, Hajer 2005). What is more, technologies themselves—such as gigantic simulation models, super computers, or satellite-based navigation systems—become participants and agents in issue framing, decision making, and warfare on the national and global level (Miller 2004, DeLanda 1991, Luke 1994). In the emerging transnational fields of governance such as forest protection and management, climate mitigation, sustainability that get added to the existing policy fields of environmental and development policies, scientific expertise and complex technological measurements and monitoring is the *sine qua non* (Litfin 1999, Mayer 2012a).

Yet understanding "expertise" requires an even more comprehensive analytical perspective. The vast globe-spanning infrastructure that has been built—and needs to be maintained—connects planetary ecosystems with data storage and digital information systems (Bratton 2015). It is a complex and constantly evolving entity that comprises physical infrastructures, digital protocols, and multiple interfaces connecting the earth's surface with the sky, large computing power, programming, data storage, and interdisciplinary research practices (Edwards 2010, Ribes and Lee 2010, Bowker et al.

2010). As such, information infrastructure adds yet another layer to the previous technological systems and infrastructures from the nineteenth and twentieth century (Winseck and Pike 2007, Müller 2012). In short, our civilization is not merely depending on technologies. It is literally *made of* the intertwining and superimposing of software and hardware within global infrastructures such as channels, train systems, airports, electric grids, satellites, cloud computing and so on. As information and knowledge thus are never floating freely, they are never isolated from social, physical, and increasingly digital elements and carriers. The increase of algorithm-based high-speed financial transactions, in this sense, is an example of the trend of acceleration while it embodies this generic infrastructural interweaving. The merging of what is human and non-human on the one hand, and of the "real" and the "virtual" on the other, is most tangible through the enlargement and confluence of ubiquitous computing and virtually augmented realities present in warfare and metropolitan environments (Der Derian 2009, Graham, Zook, and Boulton 2012, Kendall 2004).

While the transformative power of technologies domesticates the globe by mastering geographic distances, another crucial dimension lies in their involvement in processes of commodification. Marxist analysis especially stresses how technologies enable and intensify processes turning "raw materials" into goods for capital accumulation (MacKenzie 1984a, Clack and York 2005). With accelerating pace, new stuff is produced, consumed, and circulated: for instance, through global waste and recycling processes, as chemical particles in food, as manufactured products, and so on (Appadurai 1986, Jackson 1999, Castree 2004). The relentless introduction of new commodities, in turn, adds new components to the "world of stuff' (Leonard 2010) that is rendering our material civilization ever more complex. Academic research coupled with bureaucratic standardization and the global implementation of intellectual property rights plays a central role in the ongoing process of the commercial appropriation of what has been left of the natural environment (May 2009).[13] Particularly, "smart" objects from cars and cell phones, to toothbrushes, e-readers and forks posses an incredible potential for the

[13] Science-based political solutions for global environmental problems such as CO2 emissions, deforestation, or biodiversity often lead to further commodification (Brand 2010, Methmann 2011, Stephan and Paterson 2012).

commodification of information about human activities:

> "Essentially, the ability to insert a sensor and an Internet connection into everything, including our body, makes it possible to commodify everything and to attach a price on the information generated in the context of its use. Sensors and ubiquitous connectivity help to create new, liquid markets in such information, allowing citizens to monetize self-surveillance" (Morozov 2013)

Finally, the fact that technological innovations often lead to fierce public controversies also indicates their deeply political nature. Technological controversies that happen despite a largely instrumental and technology-friendly public and academic discourse (cf. Forman 2007, Sveiby, Gripenberg, and Segercrantz 2012), leave visible traces illuminating the interests and concerns of differently-affected actors. In this line, chapter 2 illuminates how novel weapon systems and infrastructure have remained essentially contested in their meanings and consequences. The evolving intellectual and practical apprehension of new technologies is not only relevant for defense and security, but also for energy and gene-technologies. Studying the forms of resistance against technological "progress" leads one to refute two misleading perspectives: on the one hand, Sachs (1991) and Escobar (1995) convincingly criticize development discourse because it systematically depoliticizes technologies under the ideological guise of economic development and social progress. On the other hand, scholars such as Vandana Shiva carve out how deterministic renderings of technologies silence the variety and legitimacy of public contestation.[14] The mapping of technological controversies, hence, illustrates, against instrumentalist and determinist approaches, that concrete technologies are contingent upon various cultural influences and political rationalities. Temporary stability—or structures—is an effect of collective "bargaining" among human and non-human actors while essential categories of life and humanness often had shifted (Latour 2005, Jasanoff 2011, Barry 2012).[15]

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[14] The global extension of Western-style intellectual property rights prompts resistance, backlashes, and creative re-appropriations (May 2009). Shiva's work (1994) exemplifies how the perspective of contestation, analytically, reveals the global politics and the networked power, which are involved in modern technologies.

[15] Another noteworthy approach, which will not be followed here, would be to rely on scenarios that simulate the breakdown of major technological infrastructures such as electricity supply of communication

The development of autonomous lethal military robots offers an interesting example of the destabilizing nature of technological controversies. As the Pentagon premiered the "first openly declared national policy for killer robots" in 2012,[16] the actual employment of semi-automatic weapon such as robots and drones, which increasingly complement or supplant human soldiers, has stirred fierce debates within the USA (Marchant et al. 2011). Meanwhile, both nongovernmental organizations (Human Rights Watch 2012) and the UN call for a strict ban against the development of "killer robots" (Crossette 2013). Even outspoken supporters of self-controlled weapon systems (or whole combat units) warn against a seemingly irresistible trend of dehumanizing warfare. Writes retired lieutenant colonel and military strategist Thomas Adams:

> "Once this progression of ever more capable machines began, the US armed forces, and those of other advanced countries, started down a road that will probably remove warfare almost entirely from human hands. (...) More and more aspects of war fighting are not only leaving the realm of human senses, but also crossing outside the limits of human reaction times. The effect of these trends is already being enhanced by the emergence of directed energy weapons with their capacity for engagement at the speed of light. In short, the military systems (including weapons) now on the horizon will be too fast, too small, too numerous, and will create an environment too complex for humans to direct. Furthermore, the proliferation of information-based systems will produce a data overload that will make it difficult or impossible for humans to directly intervene in decision making" (Adams 2001, p. 2)

At stake are the unmanageable intermingling of humans and robots on the one hand and the cyborgization of humans on the other are (Singer 2009). The understanding of the tactical and the strategic possibilities and consequences of these cutting-edge weapons is still very limited, whereas pressing ethical and political questions are already on the table (Asaro 2008, Jenks 2010).[17] The very definition of war is changing: Peter Singer concludes that the use of inappropriate vocabulary signifies "we can't yet conceptualize exactly what these technologies are and what they can do. It is also because their

systems. The politics of technological breakdowns perhaps could be modeled to offer insights about real-world dynamics.

[16] See http://thebulletin.org/us-killer-robot-policy-full-speed-ahead.

[17] A parallel controversy arose about the predominance of algorism-based computer trading that counts for up to 75 percent of stock market trading (Steiner 2012).

nonhumanity sums up their difference from all previous weapons. It is why their effect on war and politics is beginning to play out in such a new and revolutionary manner." (Singer 2009, p. 430)

If one takes these transformations into account, as well as their relevance for security, political decision-making, and governance, then it becomes clear that most standard explanations and models of IR are unable to capture their complexity. The fuzzy politics inherent to electricity grids, social networks, or virtual money leave an unsettling impression—entailing unpredictable interconnected processes, unorthodox linkages between all kinds of actors, and contradictory policy trade-offs. Even at a superficial glance, the puzzles arising from this can hardly be framed in dichotomies such as high versus low politics or state-market and state-society binaries. Not only do state-centric explanations seem inadequate, but even the distinction between humans and non-humans is called into question. Against this background, it becomes clear that the conceptual language and theoretical framework needed for technological innovations have to render intelligible, broadly speaking, hybrid processes of becoming, and should not privilege any actor in advance.

1.4 Outline of the book

My argument is structured into four consecutive components. The *first* part of the book (Chapters 2 and 3) advances a historical view of the connection between technological innovations and international relations. Chapter 2 utilizes the metaphor of "technological dramas" (Pfaffenberger 1992a) to further elucidate the paradoxes of technological innovations that spring from an IR point of view. By elaborating three puzzles it becomes obvious that both technological determinism and social constructivism cannot comprehend the ambiguous politics of technological innovations. The history of global power shifts, modern state formation, and twentieth century security practices demonstrate that emerging technologies are neither mute, passive instruments nor determinative forces but, can enable, constrain, or undermine social practices and the exercise of power. The puzzle of the "great divergence", for instance, illustrates the process-character and long-term consequences of innovations. Their effects are characterized by complex feedback loops and diffusion dynamics that are at the same time technical, political, commercial and cultural. The ability of governments to anticipate how certain technological innovations change warfare and security is almost nonexistent—not to mention the incapability to control weapons systems effectively from evaporating. Chapter 3 turns to eminent theorists such as Karl Marx, Joseph A. Schumpeter, and Harold A Innis who explained the elusive consequences of waves of technological revolutions in illuminating ways to inform theorizing agency and change within IR confines.

The *second* part (Chapters 4 and 5) interrogates the "lightness" of IR. In Chapter 4, I trace how technological change, after a phase of intense attention paid to it during the 1950s and 1960s, vanished from the radar of the discipline. It became, in what constitutes a unique drift away from other social sciences, inconsequential for theorizing in IR: neither established as an epistemic field commanding its specialist community, nor a distinct set of empirical concerns and theoretical assumptions. A close examination reveals that IR scholarship assigns technological innovations, if anything at all, a merely implicit or exogenous role. Subsequently, it is argued that the silence about technological innovation is not merely due to coincidental moves on the conceptual level but rather the result of the "Cartesian complex"—that is, a combination of logocentric bias at the ontological level, dualism at the conceptual level, and academic compartmentalization at the practical level explaining much of IR's lightness. As a result, IR operates as a *social* science that deliberately excludes non-humans, materials artifacts, technologies, and hybrid modes of agency. Thereby a foundational neglect is perpetuated that legitimizes the discipline's generic lightness. Despite a celebration of theoretical diversity, this 'monocultural' condition has remained largely hidden because the foundational debates in IR were mostly preoccupied with the intricacies of epistemology. The fixation on men's minds and ideas, and their arcane "social" interactions, norms and "discursive" articulations is well in line with a continental European philosophical tradition (Braver 2007). It results in research designs that ignore the existence of materiality—material agency, technological practices, and the opalescent, networked emergence of bodies, artifacts, and ideas stressed by science studies. Only recently has the logocentric onto-politics become disputed. Work on technological politics attempting to escape IR's ingrained Cartesian framework that follow the idea of "coproduction" are the most promising option to frame alternative theoretical puzzle.

The *third* part of the book (Chapters 6 and 7), building upon historical materials and the literature review, turns to a fundamental level, pondering how to replace notions that render a 'massless' version of the world self-evident. Drawing on ontological and epistemological understandings from anthropology, innovation economics, and science studies, I put fourth a post-Cartesian meta-theoretical approach. This program of "explorative realism" does not primarily touch upon epistemological concerns, many of which have attracted undue attention during recent scholarly debates. What is at stake is rather the recognition of the limited ontological parameters of disciplinary thinking in IR. The question arises which onto-politics would enable us to capture, comprehend, and conceptualize transformative properties of technology. Hence, Chapter 6 highlights an *explorative* function of theories. Theories are, among other things, "foundational collectors" that enable researchers to discover uncharted territories rather than only "explaining" known puzzles. Only after the work of assembling—by means of ethnographic methods and foundational collectors—follows the theoretical comprehension of the distribution of agency and group formations. Against premature metaphysical closure, explorative realism hence challenges the philosophical foundations of the discipline that ultimately sustain and legitimize the lightness of IR. Epistemologically, scientific knowledge is not seen as an independent academic product. This view abandons correspondence models of scientific knowledge (that usually seek to establish causality or the objective constitution of social facts) and embraces the view that exploring, knowing and writing, in practice, is always related to collective activities within and outside the scientific community.

This meta-theoretical move aims at linking two progressive hotspots within contemporary IR: On the one hand, it rallies for *ontological expansion,* specifically in terms of processes. Despite the work of James N. Rosenau, John Ruggie, and Patrick T. Jackson among others, the process-character of technological innovations is difficult to discern because much of the discipline—even when discussing changes and shifts—relies, by and large, on stylized equilibrium models, static notions, and stabilized sets of actors. On the other hand, this book advances the agenda of a nuanced "materialism" in studying global politics (Braun and Whatmore 2011, Connolly 2013, Squire 2014). In particular, making sense of the messy material landscapes implies transcending both the conventional logocentric bias and dualism. Under conditions of coproduction, the domains of reality that have been separated by the Cartesian tradition are reconciled; the technical, the natural, the cultural and the political apparently converge. Drawing, on STS (Mitchell 1998, Hecht 1998), the umbrella term of "techno-politics" replaces the binary opposition often invoked when IR conceptualizes technological agency (Mayer et al. 2014a). The development of a post-Cartesian IR, in this sense, does not seek to strike a better balance between "material" and "ideational" factors," as critical realists propose (Wight 2006). It rather subscribes to a monist view (Jackson 2011) in that technology is neither external to the construction and stabilization of political order, nor is "politics" and the interaction of political collectives comprehensible without its material components or technological mediation (Matthewman 2011, Law 2004, Jasanoff and Kim 2015).

Chapter 7 sets out a substantial program of *ontological expansion* that is at the heart of explorative realism. Revisiting the limitations of IR understandings of technological innovations, ontological expansion is made intelligible through a framework that maps theories (or rather "foundational collectors") onto four quadrants: the first axis distinguishes between dualist and non-dualist approaches to IR. The second axis distinguishes between ontological notions with prefixed entities and levels versus ontological notions that stress emergence and stabilization of collectives. Approaches located in the "double mixed-zone", which transcend both static assumptions and the mind-matter-dualism, are especially promising to explore technological innovations. The "double-mixed zone" is intended to support empirical research about processes of emergence and symmetrical inquiry into heterogeneous agencies (cf. Coole 2013, p. 465). It also embodies a *relativist* paradigm, implying that IR scholars avoid treating time, space, knowledge, artificial objects, and built environments as constants. Such a relativist commitment of explorative realism, then, allows for the discovery of new empirical landscapes and alternative puzzles about the politics of technological innovations and to develop a post-Cartesian.

The *fourth* part (Chapters 8 and 9) operationalizes these meta-theoretical considerations, suggesting a conceptual framework for the study of technological innovations. It outlines the notions of "assemblages" and "creative destruction" in order to capture the transformative effects of technological innovations. The former term signifies heterogeneous actor-networks entailing both humans and non-humans that have, as analytical units, a mid-range size. The latter conceptually sheds light on the ways in which technological innovations alter or destabilize prior group formations across all levels through interrelated processes. Employing a series of illustrative empirical cases, Chapter 9 outlines a three-part theoretical model consisting of assembling, reassembling and disassembling. In developing this tripatide model, I particularly draw on two theorists. With Joseph A. Schumpter, I stress the significance of human creativity, temporary monopolies, and non-linear shifts in the context of non-equilibrium changes. Complementarily, I employ sociologist Bruno Latour's work on actor-networks and translation to acknowledge the need for a symmetrical methodology and a flat ontology to make sense of a collective agency always mediated by artifacts.

Explorative realism, in sum, implies conceptual reconstruction writ large. To conceptualize creative destruction requires rearticulating central IR concepts such as power, authority and agency and offers novel socio-technical topologies, forms of knowledge and domination, accounts of emergence and disappearance. The very nature of technological innovation that involves controversies about group formations, agency and actuality explains some of the fundamental problems complicating comprehension. But questions of collective action, agential power, and the construction of political order do not simply "dissolve into thin air". They rather turn into *empirical questions* for research. The idea of creative destruction does not only move one beyond disciplinary routines of IR scholarship. It also tries to uncover the unspeakable, especially in processes of disassembling where our conceptual apparatus are unable to express the ambivalent and elusive phenomena we encounter.

From the outset, this undertaking constitutes a daunting task. Chapter 10 discusses the advantages of taking artifacts, technical system and the coproduction of order seriously within IR. In particular, it would not just render IR relevant as a critical "public" science, employing a strong sensibility to postmodern political concerns. It also opens up alternative research puzzles and conceptual tools, widening the one-sided metaphysics of IR. However, such an endeavor inevitably leaves many traits untraced and posits novel questions without being able to answer or address them. In addition, the price that one must accept to pay for removing IR's "lightness" is considerable. Acknowledging the complexity of technological associations cuts across conventional conceptual and meta-theoretical delimitations that are the firm ground upon which many IR theories and schools rest. Various concepts of IR theories are in need of refashioning. For example, the notion of assemblages requires an elaboration of the "productive" character of power beyond what has been attempted thus far. Disencumbered from its Weberian heritage, the term refers to the ability to "act in concert", entailing as many actors and elements as empirically discernable, and creating not only subjectivities but giving rise to entire modes of existence. Similarly, to take materials seriously renders IR, even more than before, into a process-oriented effort of theorizing while it leads to alternative mappings of the world that may seem far-fetched.

Yet I believe that this meta-theoretical stance of explorative realism offers a promise for theory building in IR. It supports a methodological move to recognize and explore the real multiplicity of the world. Against the inclinations of an "applied social science", my considerations deliberately propose "grand" questions, touching upon the limitations of disciplinary knowledge production. In line with Michael Williams "willful Realism" (2005), explorative realism as a methodology is inherently critical to the extent to which it reveals how the preponderance of epistemological concerns translates into ontological closures disrespectful to the multiplicity of actors, agencies, and processes that perform world affairs. So, while it is not my goal to offer concrete policy recommendations or to immediately call for critical intervention, this research suggests de-emphasizing epistemological struggles within IR.

Moreover, a symmetrical reading of world politics rejects, on the one hand, the various forms of technological determinism (see Hughes 1991, Wajcman 2002) that are a recurring feature of popular discourse, and avoids, on the other hand, the logocentric reductionism that still characterizes most IR literature. The model of creative destruction developed here opens up the material or heterogeneous forms of agency to empirical research and advances a distinctive way for IR to speak back to STS. This move also bears on the politics of knowing a technologically mediated world. If IR were to serve the public good, it would be dangerously a-political then to treat technologies—as global technocratic, scientific, and bureaucratic elites with their yearning for “technological fixes” often tend to do—in a purely instrumental way. My research perspective sheds light on the negative sides of the popular hype with “disruptive technologies” (see Harvey 2006), while gesturing at options for democratic participation in decision-making processes concerning technological innovation—a pertinent issue that is increasingly crucial for global economic and environmental governance.[18]

[18] See Beck (2012), Jasanoff (2003) and Demeritt (2006).

2. Global technopolitics: the drama with technological innovations

This chapter explores how the transformative effects of technological innovations mentioned in the introduction are intimately connected with international and global affairs. In *The Global Transformation*, Barry Buzan and Geroge Lawson (2015) point out that massive technological and political changes have reconfigured the entirety of global politics during nineteenth century. Although this period of history has put into place the key aspects of current international relations, it has not been given much systematic though in IR. While Buzan and Lawson aim for conceptual simplicity and impose a systematic approach to study the effects of this great transformation, I follow here a different and more cautious path by employing the metaphor of “technological dramas”.

The notion of “technological dramas” captures the characteristics of technological innovations: the interplay and mutual constitution of politics and technology—that is, global techno-politics—are complex and paradox processes to understand and theorize. For technological innovations display a high degree of fluidity and contingency. It implies that the implementation and the usage of technologies are not merely limited to overcoming technical obstacles or developmental gaps. The “drama” implies going beyond instrumentalist understandings: new techniques, instruments, machines, or weapon systems involve full-fledged political struggles, appropriations, counter-significations and so on (Pfaffenberger 1992a). This is similar with the view of Marshall McLuhan and Bruce R. Powers (1989) who also stress that new technologies stay unpredictable because they may always have various counter-intuitive consequences: „What will the technology extend, enlarge or enhance? What will it erode or amputate? What will it reverse or flip into when pushed to its limits? What will the new technology retrieve that earlier technologies had rendered obsolescent?” (Duvall and Havercroft 2008, p. 771)

After appreciating the sensibility for conceptual dichotomies (2.1), the drama of technological innovations is subsequently explored in four parts. Upon studying empirical cases and thematically organized three broader IR puzzles, I emphasize core characteristics of technologies on the one hand while interrogating varieties of technological determinism on the other. The paradoxes raised in the introduction are thereby reexamined by interweaving historical and contemporary reflections about links between technological innovations and Europe's hegemony as well as the emergence of the "great divide" (2.2), developmental policies by rising industrial powers (2.3), controversies about security, defense and warfare (2.4). These historical examples illustrate how practitioners and observers, just as scholars today, have faced immense difficulties in grasping the interplay between new technologies, power shifts, states, and security. They challenge the conventional wisdom of IR because technological innovations display an almost impenetrable ambivalence and dynamic throughout their evolution. In brief, the following subchapters set the stage for developing the analytical framework that put forward some basic considerations on what sort of conceptual toolbox may we will have been provided to replace dichotomist and determinist understandings without totally losing analytical rigor and explanatory strength. In order to clarify in which ways their theoretical vocabulary and conceptual approach escaped determinist models of thinking, Chapter 3 will come back to this theme and interrogate three classical theorists of socio-political and economic change.

2.1 Technology and the material-social dualism

As this chapter attempts to set out more clearly the actual difficulties for theorizing technological innovations, it probes into the reductionist enigma at the heart of all the involved political and philosophical controversies. It is contentious whether technology shapes, produces—if not determines—social institutions, interests, and norms, or vice versa. Indeed, the attribution of social change to technology (or its denial) has attracted scholarly attention for a long time and has provoked a vast ensemble of diverging arguments and debates in several social sciences (see Heilbronner 1994, Matthewman 2011, Mitcham 1994). To navigate through this epistemic labyrinth is not easy. Usually, scholars in social science have distinguished between two larger groupings, each of which belongs to a distinct philosophical tradition: technological determinism on one side and social reductionism on the other (Hughes 1994, Bijker 1993, Fritsch 2011). In the following, these common philosophical positions are though confronted. I argue that this seemingly contradictive, yet mutually reinforcing and dichotomist constellation shall be renewed for reasons that become obvious below.

“Technological determinism” comes in varieties. In general, it views the historical evolution of social formations and international power distribution as an expression of underpinning material conditions (Smith and Marx 1994, Deudney 2000a). Bimber (1994) distinguishes between three versions: Technologies cause or determine social relations (“hard determinism”). Or they constrain, enable or necessitate social relations (“soft determinism”). Finally, technological determinisms can also affect society as a form of powerful ideology that embraces technical changes as inexorable (“discursive determinism”). Social constructivist approaches, by contrast, construe technology (and by extension the entire range of material objects) as without *direct* effects upon society and politics. Intentional actors, rather, collectively assign functions to technologies, shape their properties, and utilize them for social purposes (cf. Woolgar 1991, Brey 2003).[19] The central tenet of social constructivism is that if technologies affect collective intentionality, meaning, or norms this is never due to their intrinsic qualities and always in a socially mediated manner, for example, through the attribution of symbolic meaning (Searle 1995, Collin 1997).

Do we have to accept this common dichotomy and, hence, choose one side? The historical puzzles presented within this chapter support a different view. Highlighting the dynamic and elusiveness of emerging technology, the point is that these conflicting choices both are mistaken. Approaches reducing everything relevant to the “social” or the “technical” are similarly flawed. When we deconstruct the two specific forms of reductionism, their interconnection too becomes unearthed. Notably, both camps have fundamental notions in common. At stake is the deep-seated sociological distribution “between people on the one hand, and machines on the other. Or between 'social relations' or 'social structure' on the one hand, and the 'merely technical' on the other.” (Law 1991b, p. 8) Our conundrum therefore consists in finding *appropriate* conceptual tools that do not rely on a dualist matrix.[20]

[19] Radical constructivists even do not view technological artifacts as instrumental. They rather claim that material and social reality totally depends on intellectual or textual acknowledgement (see Chapter 3).

[20] Scrutinizing alternative abstractions is therefore not identical with denying the need for theoretical abstraction in general. I believe that we can and should abstract from history and the empiric world we explore. It follows that a certain degree of reductionism makes sense, however flexible and open our concepts may be. Otherwise we would agree to completely abandon explanatory rigor (cf. Bijker 1993, p.

> "Sociologists (...) tend to switch registers. They talk of the social. And then (if they talk of it at all which most do not) they talk of the technical. And, if it appears, the technical acts either as a kind of explanatory deus ex machina (technological determinism). Or it is treated as an expression of social relations (social reductionisms). Or (with difficulty) the two are treated as two classes of objects which interact and mutually shape another." (Law 1991b, p. 8)

According to John Law, this unbridgeable divide stems from "the absence of a method for juggling simultaneously with *both* the social *and* the technical." (Law 1991a, p. 8) It is precisely the theoretical abyss between the "social" on the one hand, and "technology" on the other, that the usual categorical order presupposes—and then leaves unexamined—is the location where this investigation directs the research focus. Of course, Law exaggerates in making the distinction so sharp. It does not fully cover scholarly diversity as different types of technological determinism such as "hard" and "soft" approaches can be distinguished. In addition, many scholars aim at partly leveling the playing fields between machines and humans, an issue I will revisit below. Nonetheless, most social science approaches to technology and particularly within IR are shaped by the division between an inanimate machine or natural world governed by causality and the subjective domain of human activities. This divide and the Cartesian complex of determinism, externalism and logocentrism (see Chapter 3)[21] that has hampered IR's comprehension of technological innovations are mutually reinforced.

2.2 European dominance, path-dependencies and global flows

This section reconstructs the technological dramas that evolve around the puzzle of a large-scale power shift, the ascent of European empires. It thereby sheds light on three main characteristics of global techno-politics: complex path-dependencies, dynamic, non-linear flows and feedback cycles, and the real yet contingent power effects of different technologies for the expansion and competition among European empires. To begin with,

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128). But, as will be argued throughout this thesis, to retain enough analytical sensibility is absolutely paramount in this regard.

[21] This commonality also points to another chasm which is discussed in Chapter 5: the fundamental distinction that springs from dualist understandings of ontology and monist forms of ontology (see Wight 2006, Jackson 2011).

many historians, sociologists, and economists came to understand that technology figured a central factor within global power shifts and divergent socio-economic trajectories across societies.[22] Most of them, however, have not agreed upon explanations of how and to which extent novel technologies have shaped historical events, and the rise of Europe in particular. For instance, Jared Diamond's, *Germs, Guns, Steel* attempts to explain power differences. He pictures various technologies as significant for diverging societal developments: military and maritime technology, centralized political organization, written information and archived knowledge are, to him, "proximate factors, which also enabled modern Europeans to conquer people and other continents" (Diamond 1999, pp. 80-81). Ultimately, however, technical differentials and technological gaps, according to Diamond's analysis, are due to geographical and environmental conditions.

Many scholars do not agree with this understanding. Europe's superior technological trajectory, in their view, is not just ephemeral, ultimately stemming from favorable geographical factors akin to a geopolitical notion of *longue durée*.[23] Against structuralist explanations, they trace the principal causes of Europe's comparative advantages to ingenious individuals and pluralistic societies that were mastering natural science, empirical research and progressive inventions. The central point advanced by these authors is that the achievement of technological leadership ultimately explains Europe's later ascent to a dominant position (Ferguson 2011, Mokyr 2002, Goldstone 2009, Allan 2009, Landes 1969, Parker 1988). This view, of course, is not new. It mirrors the prevailing discourse of the nineteenth century when Europeans referred to India, China and Africa as backward regions (Adas 1990, pp. 153-210). Technological innovations and scientific artifacts figured as the most powerful indicator of this asymmetry.

> "European observers came to view science and especially technology as the most objective and unassailable measures of their own civilization's past achievement and present worth. In science and technology their superiority was readily demonstrable, and their advantages over other people grew at an ever increasing pace. This was particularly true after Europe

[22] See e.g. Sombart 1911, Schumpeter 1934/2008, Landes 1969, Cipolla 1967, and Innis 2007, Headrick 2009, Hugill 1999. Roland (1993) discusses the recent renaissance of historical appraisals of the crucial role played by technological changes for historical developments.

[23] See Kinser (1981, p. 67). Braudel's framework will be discussed in more detail in 3.1.

> and its North American progeny entered a new phase of industrial development based on steel, electrification, and chemical production in the last decades of the nineteenth century. Prominent social theorists and policymakers drew varying, often conflicting, conclusions from the undeniable fact of Europe's material mastery and its concomitant global hegemony, but few disputed that machines were the most reliable measure of humankind." (Adas 1990, p. 134)

So, can we explain the expansion of European empires merely by their superior technologies? It is safe to say that the "prime movers" of at least 200 years of global economic integration (and domination) have been invented and commercialized in Europe and the United States (Smil 2010), although, as will be discussed in a minute, European innovators indeed have greatly benefited from imported knowledge. Among the most impressive inventions that have been employed in modern Europe are shipbuilding, mechanical clocks, steam and gas engines, global communication networks, aircrafts and electric power systems (Headrick 1991, Rosenberg, Landau and Mowery 1992, Nickles 2003). Long before the scientific and industrial revolutions, Europeans had already seized the technical edge in shipbuilding and artillery. Carlo Cipolla pictures in his magisterial work *Guns, Sails and Empires* the Caravels and Galleons with their powerful canons as the crucial instruments that enabled rapidly expanding colonial empires via sea. At the same time, European land armies were repeatedly defeated, for instance, by Indians or the Ottoman Empire, showing Europe's still only partial advantage (Cipolla 1967).

It is important to notice that Cipolla's narrative does not confirm an instrumentalist understanding of technology. Assuming merely the application of devices makes little sense if one considers the daunting challenges at that time. Portuguese sailors, for example, could not have solved the most daring navigational challenge, the passage down the south Atlantic passing Cape Bojador, by using the superior firepower of their Galleons. This innovation rather required a fascinating networking process that lumped together shipbuilding, sailing skills, navigational practices, the enactment of rivaling spatialities and "fluid technologies", not to mention immense courage (Law 1987, 2002). Against this networking process, linear-determinist accounts of Europe's ascent, not surprisingly, are manufactured on shaky epistemological grounds.

The main reason is the elusiveness of why and how inventions occur and innovations cluster locally. Although they have undeniably lasting and powerful consequences, the majority of individual innovative developments made sense only in retrospect. Preexisting "demand" was only in very few cases the origin of innovative activities, whereas the opposite is the rule. Inventions that turned out to have groundbreaking implications, or to yield huge profits, such as for instance the steam engine, light bulbs, the combustion engine, long-distance communication, and so on, were initially often deemed economically adventurous. In addition, numerous inventions faced fierce political, religious or social opposition (Mokyr 2002, Usher 1954). In sum, technological progress has not occurred in a linear fashion and does not display recurrent patterns. Simple explanations for innovational dynamics are thus implausible (Mokyr 1990, Pomeranz 2000), while the non-linear features of technological innovation challenge linear narratives that link Europe's ascent to technological mastery.

To put it differently, explanations for innovations are thus mostly restricted to the ex-post facto mode. The peculiar nature of novelty renders anticipative impact assessment of innovations impossible as a matter of principle (Witt 1996, p. 124). For the magnitudes and peculiarities of an invention's political and social effects are often emerging unexpectedly. Innovations have often opened up a new world that only few have entertained in their wildest dreams and speculations. The history of petroleum—often seen by scholars as seminal example of the global impact of technological change (Buchan 1972)—is a case in point. Its pioneers kept a "low profile", as Daniel Yergin notes in the *The Prize*, for they preferred concealing that they were "involved in so speculative a venture." Actually, nobody could have foreseen the cascade of scientific and commercial innovations, which led to a development that today predominates our societies, economies and politics (Mitchell 2011, Mayer and Schouten 2012). In the 1850s, very few people imagined large oil deposits beneath the surface; very few saw in "rock-oil" the coming source for illuminating the world's home and factories; very few understood that "drilling" rather than "digging" was the way to exploit crude oil; many were opposed to pipelines in the 1880s; nobody seriously considered petroleum as fuel for combustion engines in cars before 1900; in 1911, Churchill had to be convinced to shift the British fleet from coal to oil; at the start of World War II, few foresaw the central role of petroleum; the US military did not even have records of its oil use supplies; by the end of the war, the US oil production was up from 40,000 barrels per day to 514,000 barrels per day of high quality 100-octane. By then, various technical innovations had helped to meet a “demand” that was simply inexistent prior to the first “war of motion” (Yergin 1993, pp. 19-113; 153-156; 382-384). Later, however, US oil production was in decline for decades despite constantly rising demand.

The sequence of the discovery, the exploitation, and the usage of petroleum illustrate the restricted explanatory power of “demand models”. Most innovations, regardless whether incremental or radical, did not stem from preexisting needs. Yet, as Wiebe E. Bijker’s work on the decades-long formation of bicycles and light bulbs shows, these innovations require a group of social engineers to envision and pave the way for their actual use. During a process, they eventually have “created” their economic necessity as well as new social practices (Bijker 1997, Bijker and Law 1992). Analytically, such a historical understanding also multiplies the assumed motivations of innovative behavior. Myriads of different motivations for innovation are possible, while pressing demand structures, profit incentives, or technical lacks can neither force nor constrain innovations to become real. Theoretically speaking, the often contra-factual and stubborn agency of innovators (and pioneer users) is a crucial aspect of techno-dramas.

It is contested as to which explanations for the origins of technological innovations follow from their contingent occurrence and sequence. If we reason to one extreme, we could claim that success of inventions is coincidental. Claude Lévi-Strauss (1956), for example, proposed that the breakthrough of technological developments and consequential societal transformations couldn’t be attributed to certain cultures (or races). Regardless of their whereabouts they would have developed essentially along familiar lines: “We can therefore be sure that, if the industrial revolution had not begun in North-Western Europe, it would have come about at some other time in a different part of the world” (Lévi-Strauss 1956, p.152). On the contrary, others claim that the uniqueness of local conditions is absolutely pivotal for inventions to be put into practice and to gain momentum. As such, technological innovations require peculiar legal, economic, and cultural settings in order to materialize and, in turn, to become powerful enablers of social change up to the scale of industrial revolutions (Pomeranz 2000).

By implication, and going beyond a set of environmental conditions, we can also differentiate between, on the one hand, the path-dependency of specific types of technologies, which clearly exists as the accumulation of technological innovations cumulatively builds on earlier stages of the same or related technologies. Path-dependency, in this context, is understood as co-evolution of technological systems and artifacts.[24] On the other hand, the existence of other, previous unrelated, technological systems, applications, and artifacts is also an important precondition (Mitchell 2009, Misa 1994, p. 122). For example, while the proliferation of automobiles often preceded the necessary traffic infrastructure, leading to high death tolls and traffic jams, the "car" is only fully realized with the extension of highways, streets, cheap fuel and a comprehensive availability of gas stations and repair shops (Volti 2008).

The effects of path-dependency, however, are limited. The state of existing technologies is a necessary stage for new inventions, yet not a sufficient one (Ayres 1961, Lawson 2008). Against expectations of incrementalism, innovations and their complex interactions and entanglements are often evolving abruptly. Inventor and futurologist Ray Kurzweil (2006) sees their pace even accelerating and partly exponential in momentum. Indeed, the entire process of creative destruction (which is elaborated in Chapter 9) hardly follows an undetermined and thus incalculable path. In fact, another crucial limitation of path-dependency is that a technological progress is not inevitable so as a technological superiority is neither irreversible.

In this line, the case of the China empire has provoked Joseph Needham's famous question of why a society, given its highly advanced development stage during the Tang, Song, and Ming Dynasties, did not turn into a hotbed of industrialization and scientific revolution (Landes 2000, Perdue 2006). After all, it would have been much expected that global travelers such as Marco Polo or Ibn Battuta between the thirteenth and fifteenth centuries could arguably strike the industrial revolution in Imperial China, which at then had a long record as a technological frontrunner and produced far more advanced weapons, transport techniques and astronomic and medical knowledge as well as strong engineering and science (Mokyr 1990, pp. 209ff.). But, despite China's earlier

[24] Many scholars point to commonalities between technological and biological evolution (Mokyr 1990, p. 283, Lem 1981, pp. 25ff).

technological edge, European empires, trading companies and later nation-states have managed to catch up and, employing their superior weapons for example during the Opium war, even achieved a dominant military position.

We need to be cautious for, to the extent that technological catch-ups are reversing earlier technological dominance, they are always embedded in global flows and feedback processes. In this vein, recent scholarships qualified the premises of Needham's problem; they rejected a simplistic narrative that reduces Europe's technological trajectory to a linear matter, as Europe's emerging scientific and technical hegemony was a messy process. Andre Gunder Frank stressed, in contradiction to euro-centric perspectives, that western exceptionality and superiority has not unfolded with a preordained trajectory (Frank 1998, see also Goldstone 1993, Watson and Bull 1984). To begin with, well into the eighteenth century, Europeans had a hard time integrating into a then Asian-dominated global trade system because of economic and technical gaps.[25] While getting wealthy through the exploitation of abundant resources and cheap labor from the Americas, European merchants and the first joint stock companies experienced worrying trade deficits with their Asian counterparts up until the eighteenth century. The reason was that artists, mines and manufacturers had—aside from silver and mechanical clocks—few products at their disposal that were interesting to foreign consumers and sophisticated enough to prevail on Indian, Arab, Japanese, or Chinese consumer markets.[26] As a consequence, the French, Spanish and British rulers erected trade barriers to slow down the imports of Asian textiles, silk and other manufactured goods (Adas 1990, pp. 26ff., Cipolla 2011, pp.100ff.).

On a larger perspective, the European continent remained a backwater until the late eighteenth century. European economies remained technologically and institutionally inferior compared to subregions in India, Imperial China or even Southeast Asia where vibrant centers of manufacturing, trade, and craftsmanship were thriving. For instance,

[25] Inside Europe, already by the end of the fourteenth century, the innovative abilities had shifted from the Mediterranean area to middle European kingdoms and city-states, as observers warned the Byzantine emperor of a growing technological margin (Cipolla 2011, p. 24).

[26] This does of course not mean that European craftsmanship was generally inferior. Instead, as Zilsel (2000) has pointed out, without sophisticated European craftsman, professionals and manual labor, no modern science could have come alive. Yet until the eighteenth century most European products remained excluded from "global markets" except in the Americas.

drilling technology had been used for over fifteen hundred years in China, but was largely unknown outside. It was only imported to Europe around 1830 (Yergin 1993, p. 25). The British Navy copied Indian missile technology in order to apply it for the attack on Copenhagen in 1807 (Fridlunt 2011). Even the rise of modern capitalism was not solely confined to Europe since both India and China had enormous capitalist enterprises, advanced manufacturing, and cutting edge technologies (Frank 1998, Das Gupta 1994, Pomeranz 1993). Neither did the retreat of Chinese fleets after Admiral Zhenghe's voyages end Chinese maritime dominance in Asia.[27] The European attempts to colonize the "East Indies" were at first uneasy enterprises. "Conquer", as Fernand Braudel put it, "is too strong a word. Very often, they were not even able to trade on equal terms." (Braudel 1992b, p. 221) In short, the exploration of how Europe's technological preponderance has occurred demands a truly global approach.

This complicates linear accounts of the early expansion of European empires. If homegrown ingenuity and indigenous scientific progress plays a role, then the technological rise of Europe must be seen primarily as a consequence of transcontinental flows of expertise and techniques. Most indefatigable, Braudel pictures the constant ebb and flow of "world economies", areas of intense exchange that, as it particularly was the case with the Mediterranean, "bestrode the political and cultural frontiers". He contends that "the economy, all-invading, mingling together currencies and commodities, tended to promote unity of a kind in a world where everything else seemed to be conspiring to create clearly-distinguished blocs." (Braudel 1992c, p. 22) In fact, a continuous process of mutual learning was the rule—including the diffusion of technologies between cultures and societies across the globe, which our current imagination perceives as separated, or at least not well connected (Cipolla 1965, Braudel 1992a, pp. 385ff).

Scientific and philosophical knowledge traveled directly from Arabic civilizations to the relatively backward kingdoms and Italian city-states, igniting early European research and humanistic philosophies and enabling the enlightenment movement. Arabic

[27] The Dutch East Indian Company, for instance, lost its profitable colony Zeelandia on the island of Taiwan. Dutch troops had to retreat to Batavia because of a crushing defeat against Chinese forces under the command of pirate-turned-admiral Koxinga in 1667. On an equally weak footing lived the Portuguese settlement in Macao, which was absolutely dependent on the permission of and food supplies by Chinese Imperial authorities (Andrade 2011).

philosophers, mathematicians and technicians, who for centuries incorporated ancient Greek philosophy, sciences and know-how, were far more sophisticated in terms of navigation, math, astronomy, irrigation, or urban infrastructure for a long period (Freely 2009). The same can be said about Sino-European exchanges. On the one hand, several Jesuits had become leading figures at the Imperial court in Beijing in charge of the Chinese calendar; on the other hand, Chinese artwork, gardening techniques, textiles, and architecture had been eagerly imported by European elites. The latter appreciated the two-way communication with the Ming Empire for mutual benefits. For instance, German philosopher Gottfried W. Leibniz, publishing his *Novissima Sinica* in 1697, saw the middle kingdom as a highly developed civilization with thriving philosophy, technical expertise, and superior political organization (Lach 1945, Perkins 2004).

The transatlantic explorations of Portuguese and Spanish conquistadores, merchants, and missionaries were quite different from the relatively selective and short-lived Sino-European encounters. They brought yet another twist in terms of technological progress as both consequence and facilitator of colonial expansion. The collection, systematization, and dissemination of knowledge about non-European cultures, societies, and environments spurred multiple philosophical and scientific responses. Novel collaborative practices within empirical science, engineering, and governance emerged from challenges of infrastructural projects in the Americas, spreading to other research institutions (Bleichmar et al. 2009, Barrera-Osorio 2010). The application of academic systems of knowledge—sometimes in form of "cultural manuals"—were also hugely influential in colonial societies for they often underpinned the production of new ethnicities, classes and other social cleavages. Meanwhile, European publics and elites largely came to understand their distinctiveness and historical mission through the prisms of "Orientalism" (Said 1976)—of which different registers had, as mentioned above, technological differences at their core.

Obviously, it was not merely military superiority that had led to the dominance of European colonial powers and later Japan and the US (Howard 1984, Headrick 1979, Buzan and Lawson 2015). The modern sciences and engineering involving the construction of technological systems, the production of expertise, and the use of novel technical artifacts were at the heart of the colonial (and imperial) enterprises (Palladino and Worboys 1993, MacLeod 2000, Mizuno 2009). Inevitably, "western scientific knowledge has been co-constituted with colonialism" in many ways (Seth 2009, p. 274). It is often overlooked, though, that through these expanding networks, technologies and practices moved in both directions. Long before the European powers created international organizations to facilitate industrial processes and enable technological infrastructures (Murphy 1994), this two-directional traffic had begun not only fundamentally altering the lives of Amerindians and colonial elites, but also transforming, for example, the territorial practices and sovereignty discourses of "international" relations on the European continent.[28]

To sum up, technological innovations are in multiple and complex ways related to the historical rise and demise of civilizations, to power shifts among empires, and to the current distribution of power and prosperity amongst core and periphery states. The global dominance of European powers rests upon a large technological infrastructure and technological superiority (Buzan and Lawson 2015, pp. 67ff). But historical evidence suggests that path-dependency can be qualified in two important ways: first, technological innovations have not, strictly speaking, determined the outcomes of power shifts; neither have they singled-handedly caused economic divergence. Second, technologies as such have never functioned as mere instruments but emerge from various global flows and lead to unexpected interactions. Typically vested in a mutative performance, they were anything but easily controllable tools at the hands of conquerors, statesmen, or entrepreneurs. Clearly, to make sense of these developments from an IR perspective we need to refine conceptual lenses through which we understand technological aspects of power shifts in international politics. But we have first to broaden our understanding of the relationship between technological innovations, authority and state regulation. After all, the question why the Europeans have not just managed to catch-up, but become champions of technological innovation needs further elaboration. This, then, involves the co-constitution of technological innovations and modern statehood.

[28] For detailed discussions of the "peripheral" sources of European modernity see Jahn (2000), Branch (2012) and Anderson (1996).

2.3 Modern states, creative destruction and developmental policies

The following empirical puzzle highlights the complex and intimate interplay between modern state formation and cycles of technological innovations. The technological drama unfolds through unsolvable tensions between the enormously difficult efforts of modern states in fostering, governing, and harnessing technological innovations on the one hand, and the social and political consequences of the maelstrom of modernization that recurrently reshuffles the socio-technical fabric of society on the other. Innovation processes, in addition, put firms and entrepreneurs in the driver seat, while state agencies often only can respond to non-linear processes that remake the very economic patterns and technological structures with which state power is entangled—sometimes over night (Chandler 1977). What renders our understanding of states so precarious, in brief, is their intricate entanglement and historically specific co-constitution with evolving infrastructures, techniques of calculation and measurement, and social technologies (Foucault 2007, Scott 1998).

The intractably close connection between the "state" and technological innovation is a particularly modern appearance (Oakeshott 1975). As van Crefeld (1999, p. 377) concludes: "the rise of the state is inseparable from that of modern technology." Scientific and economic rationality increasingly overrode religious beliefs as the foundation of political legitimacy. At the dawn of the Enlightenment era scholars, engineers and craftsmen began to cooperate in order to collectively work on machines, and to understand as well as to control nature (Zilsel 2000). From another angle, Anderson (1996, p. 41ff.) shows how the use of the printing press, and consequently the proliferation of books and newspapers as the first truly modern mass products, has changed the inter-subjective perceptions of belonging. At the same time, nascent European nation states became occupied with 'social order', which became a top-down project of deliberate engineering. States, in turn, were shaped and reproduced, among others, by jurisprudents, natural scientists, and different technical experts including their calculations, laws, and principles working towards the realization of a rational organization of the entire society (Bauman 1991, Scott 1998). Enlightenment sciences and technologies were constitutive for the manner in which societies, landscapes and places became simultaneously both manufactured and governed in modern Europe, with the effect that states emerged as an outcome of "of heterogeneous practices that objectified and invested socio-corporeity and socio-material space." (Carroll 1996, p. 162)

This unfolding co-constitution of technological and social order also became the paramount focus for scores of sociologists and historians. Their assessments of its consequences have produced widely different viewpoints. Technical expertise and technological devices were, according to Max Weber (1964, pp. 716ff.) the decisive advantage of modern bureaucratic forms of rule over all others. He diagnosed the related process of instrumentalist rationalization—a defining aspect of modernity—as having resulted in living conditions, which he circumscribed with the metaphor of the "iron cage" (Scaff 1989). By this Weber refers to the practice of increasing central control and calculation—namely, a social order "bound to the technical and economic conditions of machine production, which today determine the lives of all the individuals who are born into this mechanism." (Weber 1958, p. 181) The impression, which Weber advanced, indicates the inescapable totality produced by technological modernization.

Students of innovation stress, contrary to this view, the enormous uncertainty and openness involved in innovative processes, challenging the assumption of iron totalities. Even if the innovation of new machines, devices, and organizational modes of production is conditioned by prior existing technologies, among other things, the involved process as a whole leads to often unexpected and large-scale restructuring of economic arrangements and social circumstances. This fluidity that defied determinism is what Karl Marx's singled out when he emphasized the evolving social chaos and upheavals during industrial modernization. His gloomy vision captured the turbulent personal experience of modernizations:

> "Constant revolutionizing of production, uninterrupted disturbance of all relations, everlasting uncertainty and agitation, distinguish the bourgeois epoch from all earlier times. All fixed, fast-frozen relationships, with their train of venerable ideas and opinions, are swept away, all new-formed ones become obsolete before they can ossify. All that is solid melts into air, all that is holy is profaned (…)" (Marx, Communist Manifesto, p. 338, cited in Berman 2010, p. 95)

Joseph Schumpeter went a step further, claiming that the historic flow of innovations is the real essence of capitalism for it created a process of "creative destruction," which was the engine of economic development. In line with Marx, Nietzsche and Sombart, he stressed the primacy of processes (Elliot 1980, Reinert and Reinert 2006). This dynamic understanding led Schumpeter to refute static, equilibrium presumptions about economic activities such as those embodied in the models by Smith and Ricardo. Instead, especially "revolutionary changes" constitute the actual "problem of economic development" (Schumpeter (1934, p. 63).

> "Development in our sense is a distinct phenomenon, entirely foreign to what may be observed in the circular flow or in the tendency towards equilibrium. It is spontaneous and discontinuous change in the channels of the flow, disturbance of equilibrium, which forever alters and displaces the equilibrium state previously existing." (Schumpeter 1934, p. 64)

Schumpeter assumed that the dynamic of creative destruction, by virtue of its own success, would stop the evolution of capitalist civilization as a whole. According to his logic, constant revolutions of economic structures, in turn, are slowly eroding the political and legal institutions—in Schumpeter's (1947, pp. 131ff.) language the "protective political strata"—that, necessarily, must be in place to leave room for entrepreneurs who translate inventions and ideas into profitable business. Whereas this prediction has not materialized, Schumpeter's broader points hold some truth. Acemoglu and Robinson (2012, pp. 76ff.) concluded that politically and economically "inclusive" institutional settings remain the key to economic progress. Their study of economic performance in over hundred countries, informed by Schumpeter's ideas, showed that the absence of extractive elites and the permissive social institutions, allowing for creative destruction largely determined wealth inequalities among nations over the long term (Acemoglu, Aghion, and Zilibotti 2006). The global comparison also revealed, perhaps, it is less European ingenuity that was unique rather than the cultural and political conditions of permissiveness for the application of novel techniques or procedures (Vanberg 1992).

There is an interesting paradox here. Schumpeterian accounts granted a central role to the human creativeness and the individual ability to "get things done"—in accordance to Schumpeter's phrase. Yet, "technological determinism" arguably acted at the same time as the most powerful ideology, buttressing the process of creative destruction. For it rendered "the artifacts of technological innovation (…) to signify progress, as well as the ever-receding goals towards which we are said to be progressing." (Smith 1994, p. 38) Writes historian Joel Mokyr:

> "To create a world in which 'useful' knowledge was indeed used with an aggressiveness and a single-mindedness that no other society had experienced before was the unique Western way that created the modern material world. It is this useful knowledge that first unlocked the doors of prosperity and threw them open (…) Even today resistance to and concerns about technology are still rampant, but the institutional setup of the world is such that holdouts that reject modern technology or cannot adopt it will eventually have to change their minds and somehow limp through the doorway." (Mokyr 2002, p. 297)

Here it raises a complicated question: if, in the modern world, technological innovations are not only nearly irresistible but also largely carried out and shaped by private economic actors, what does this mean for the narrative of state-led development? For instance, the difficulties to predict trajectories of innovational dynamics hamper the ability, by companies and nations, to secure technological leadership. Conversely, late-developing states possess real chances to catch-up, although state agencies cannot simply engineer economic development. Because the evolution of technological innovation is not simply linear, unfolded in global production networks, and is driven by transnational companies (Etzkowitz and Leydesdorff 2000, Breznitz 2010, Dicken 2007). In short, no ready-tailored toolbox approach exists that guaranties innovation-based growth.

The enormous success of Germany, the US, Japan, and the Soviet Union is indicative for institutional diversity. These countries surpassed Great Britain based on the very different national "systems" or "cultures" (Nelson 1993, Hall and Soskice 2001). Drawing the lessons from success and failure, it becomes clear that governments cannot merely unleash technological innovation as they please, because the historical and sector-specific global environments are instable, hard to predict, and constantly evolving (see Breznitz 2007). In addition, the moving "technological frontier" is another important reason for the increasing *divergence* of economic policies (Fagerberg and Verspagen 2002). Fagerberg and Srholec argue that,

> "it is asserted that [development] is mainly a question of successfully 'westernising' the political system, e.g., adapting to the institutional arrangements that have proved to be successful in the United States and other western democracies. This study (…) finds the support for these assertions to be rather weak. On the contrary we show that it is among the richer economies that a political system of the Western type is shown to be conducive to growth. For the poor countries it is, if anything, the other way around. In fact, among the countries that over the years have succeeded in catching up there are several examples of countries with institutional arrangements that differ a lot from western ideals." (Fagerberg and Srholec 2008, p. 1427)

Consider for a moment the discussions in the nineteenth century. During the golden age of liberalism, commentators and scholars had not even taken into consideration state-led innovation (cf. Polanyi 1977, pp. 192ff). On the theoretical level, it appeared to laissez-faire economists absurd and reactionary to relate the abstract concept of the "nation state" to a set of actors and processes that create scientific knowledge, invent new methods or production, and push forward technological innovations. When Schumpeter published his otherwise revolutionary work *The Theory of Economic Development* in 1911 he had not parted with the mainstream thinking of his contemporaries with regard to the "state": regulations and policies got almost no attention in his theoretical account of "creative destruction". But, as Polanyi (1977) demonstrates, the rise of markets that evolved through an even and combined development on a global scale—to use Leon Trotsky's phrase—was anything but a natural process. It was the effect of deliberate political decisions and essential, often violent, transformations of human life and societal organization (van der Linden 2007).

It is also important to notice the rise of comprehensive economic planning in the wake of the First World War which created in the first place "national economies". National economies only emerged out of a "series of political implosions, social disintegrations, financial failures, and worldwide conflicts." (Mitchell 2002, p. 5) So when Schumpeter and earlier economists wrote about the "economy" they had a different object in mind than we usually imagine today.

> "The idea of the economy in its contemporary sense did not emerge until the middle decades of the twentieth century. Between the 1930s and 1950s, economists, sociologists,

national statistical agencies, international and corporate organizations, and government programs formulated the concept of the economy, meaning the totality of monetarized exchanges within a defined space. The economy came into being as a self-contained, internally dynamic, and statistically measurable sphere of social action, scientific analysis, and political regulation. (…) The economy did not come about as a new name for the processes of exchange that economists had always studied. It occurred as the reorganization and transformation of those and other processes, into an object that had not previously existed. The crises and forces that brought about this transformation (…) made possible new forms of value, new kinds of equivalence, new practices of calculation, new relations between human agency and the nonhuman, and new distinctions between what was real and the forms of its representation." (Mitchell 2002, pp. 4-5)

The German economist and activist Friedrich List was an interesting exception in that he thought differently about the organization of "innovativeness". Almost one hundred years before Schumpeter, he observed the stagnant situation of German Laenders' economic development in the 1830s, and opted for massive state "interventions". Specifically, he imagined a certain set of central policies and institutions to foster national economic progress (List 1841, cf. Garbe 1977). In general, he claimed it to be unquestionable that all nations would need to improve the educational skills of their citizens—or what contemporary jargon would label as "national innovation systems" (Freeman 1995, Lundvall 1992/2010). Against the liberal credo of his contemporaries who believed in minimal government intervention and open markets,[29] List preferred a "National System of Political Economy", though he certainly did not understand the "nation state" as we presently do (Mitchell 2002). But his conviction that entire nations need to "climb the ladder of development" let him to criticize Adam Smith. It also set him apart from liberal thinkers such as John Stuart Mill or Wilhelm von Humboldt, though both similarly

[29] Against common misperception, neither European states nor the US were champions of free trade and open markets. Across the board, governments without exception have applied—over different periods, but typically in conditions of economic inferiority (Braudel 1992c, p. 53)—all sorts of measurements such as mercantilist trade laws, property regulations, research and development subsidies, and even covered programs of industrial espionage. Depending on their relative backwardness or edge, governments aimed at prohibiting the free flow of skilled workers and technological theft on the one hand, and to protect infant industries and indigenous technologies as well as to attract an educated workforce and scientists on the other hand (Chang 2002, Polanyi 1977, p. 203).

thought education to be central for the development of individuals and the society as a whole (cf. Valls 1999, Winch 1998).[30]

List's arguments were not merely based on theoretical pondering, but rather on detailed accounts of the historical developments, among others, in the Venetian to Dutch metropolitan economies. Perhaps most crucial was his critique against resource-focused approaches to economic development (that solely dealt with land, capital, and unskilled labor). Instead, he pointed to "productive power" as the crucial force that explains the wealth of nations (List 1841). Having experienced the debates about protectionist US policies first hand, List pleaded for the state to occupy systematic functions via market interventions, trade barriers, and first and foremost state-financed education and science (Levi-Faur 1997a, Freeman 1995, p.6).

Despite the aforementioned economists' denial, kings and royal bureaucracies have sponsored research and science, while practitioners have tried to forge intimate connections between "governments", science, and education. For instance, the foundation of the Royal Society in 1660 was not only reflective of the integration of English scientists and experimenters into lively debates and impressive advances of scientific knowledge on the continent (Hall and Hall 1968), but also the starting point for a powerful history of "imperial science" that enabled British world dominance (McLeod 1993, pp. 127ff.). While the pre-revolutionary absolutist monarchs of France invested heavily in scientific education, the eighteenth century Bourbons on the Spanish throne and Portugal's kings likewise strengthened modern scientific procedures in order to retain control over their colonial territories in the Americas through the establishment of academies and research institutions (Green 1995, Goodman 2009, p.17, Figueirôa and da Silva 2000).

By the turn of the nineteenth century, the Prussian reform efforts were indicative of a wave of bureaucratic, military, and educational institutionalization that intertwined state agencies, national interests, and objective sciences more intimately than ever before. In particular, in the decades following the Franco-Prussian war, all European governments

[30] For a detailed examination of the Marxian critique of List's ideas, stressing his anachronism of "national economies", see Szporluk (1988).

ruled in systematic ways—although with diverging approaches and based on different cultural and ideological understandings. The creation of scientific knowledge, technical inventions, and innovations moved into the focus of the state. Ministries, committees, and public institutions aimed at improving the school and university systems. In addition, they installed new mechanisms in order to fund basic research and far-flung expeditions. Equally, governments were concerned with building central institutions to organize and steer science and the foundation of prestigious research centers and well-equipped laboratories (Paul 2002, Clark 1993, Green 1995). By the mid-nineteenth century, the scientific environment became increasingly competitive and a matter of national pride among the great powers in Europe, resulting in increased political support for technological progress.

However, the governing of innovations have not become merely top-down issues. Scientific progress remained a complicated, multi-stakeholder matter. For example, the "French" chemists feared to fall behind their German colleagues between 1830 and 1880. Their struggle to secure higher funding and political support inevitably involved questions of methodology and ontology, namely the acceptance of the reality of "atoms" that constituted a highly innovative proposition by "German" chemists (Rocke 2001).

Similarly puzzling is the outstanding case of Japan's rapid appropriation of foreign technology between 1850 and 1910. Nearly in complete isolation from the West for centuries of Shogun's rule, a widening rift occurred between the technical and scientific capabilities of Japan and neighboring Russia and China very suddenly (Morishima 1982). Japanese reformers were aware of the paramount importance of superior foreign technological capabilities. They appreciated shipyards, railways, precision instruments or weaving machines not in a pure instrumental sense. Because these and other new imported technologies were believed to possess a value as a symbol of being on par with the imperial powers. Modernizers in the government simultaneously tried to foster a modern-style techno-culture among Japanese citizens while creative and controversial processes of adoption and unfolded reconfiguration were at the heart of modern state formation in the Meiji period (Wilson 2005, Mayer and Petrulewicz 2012).

Differentiating Weber's understanding of rationalization, several scholars have explored the consequences of technological and scientific progress. They stress that emerging (social) technologies yield productive power, fundamentally altering the scope and dimensions of state power in practice (Oakeshott 1875a). For some, in contrast to Weber's pessimist stance, the emancipatory overtones of scientific procedures have diffused an enlightenment worldview calling for individual equality and a deliberative logic far beyond the official academies, philosophical clubs and experimental sessions. In short, experimental science became a contagious role model for emerging designs of early modern democratic institutions (Ezrahi 1990). Michel Foucault's work has highlighted yet another twist. The gradual transformation of traditional monarchic rule into forms of governmentality and, later, bio-politics framed personal subjectivities in the context of a new inescapably discursive reality. Rulers no longer exercised repressive power. Rather, complex layers of assembled techniques, tools, and binary logics started to deeply reshape peoples' behavior and thinking through self-disciplining their bodies on a daily basis. This extended the regulatory power of prior often-inexistent bureaucracies in hitherto unthought-of dimensions through knowledge-power (Collier 2009). The "state" and the "economy" were massively transformed through railways, telegraphs, microbes, newspapers, and steam engines. Technology became, in Pfaffenberger's words (1992a, p. 282), "politics constructed by technological means." The character of these relational forms of power were, as Foucault sees it, productive to the extent to which sense it created new subjectivities at the individual level and new territorial sites of contestation (Foucault 1977, 1983).

So while nineteenth-century state power by means of engineering, science and infrastructures became closely connected with daily live, bodies, territory and individual subjectivity (Carroll 2011), this does not mean that, simply, the coercive power of states also became multiplied. In fact, the expansion of technological infrastructures seemed to constitute and, at the same time, undermine external sovereignty. The "Janus face" of technologies, as van Crefeld puts it, renders power effects to reshape statehood and "power" itself. On the one hand, telegraphy, railways, and airplanes enabled another round of colonial expansions and deepened the control over and management of far-flung territories (Yang 2011, Headrick 1991). Myriads of innovations have made the modern world small, highly interactive, and densely interconnected (Bayly 2003). The infrastructures strengthened the colonial centers and finally dwarfed all remaining competitors, both state entities and ancient empires. On the other hand, large technological infrastructures such as the optical telegraph or railways put in place during and after the industrial revolution, or in the twentieth century computerized weather monitoring (Edwards 2006, p. 249, van Crefeld 1999), forced governments to coordinate more coherently their regulations even though this required a cooperation that may effectively limit their sovereign rights (Howland 2016). Science and innovations did not, as many have envisioned during the heyday of nationalism, supported self-contained units or autonomous organisms. Whereas technologies embodied the extension, in both scope and depth, of regulative state apparatuses, they undermined at the same time national borders, ultimately by "turning them into obstacles to progress" (van Crefeld 1999, p. 378).

> "In theory each state was, and still is, free to exercise its sovereignty and build its own networks to its own standards, however idiosyncratic, while at the same time ignoring those of its neighbors and refusing to integrate with them. In practice, states could do so only at the price of incurring a tremendous technological and economic cost. (…) The precise cost of isolation varies with circumstances and also depends on the size of the country in question. However, even in the case of the largest ones, it is still substantial – not for nothing has the United States, as the country with the largest economy of all, been switching over to the metric system. To avoid this cost, states had to gain access to international networks, which in turn forced them to grant foreigners access to their own." (Van Crefeld 1999, p. 380)

Van Crefeld's description comes close to determinism because technology seemingly can thrust states into collaboration against their will—but can we trust a macro-historical account which puts the self-propelled expansion of technical infrastructures into the driver seat of political changes? One could, for instance, examine the viewpoints of contemporaries. If we asked the French mathematician and engineer Henri Poincaré, he would stress the *conventional* nature of technological systems. Particularly, he saw, in line with Einstein, time as "convention" (Galison 2006, p. 324). Poincaré's assessment bears considerable weight because it was not developed in the ivory tower. He rather had first-hand scientific and political experiences as negotiator and organizer of France's participation at the interlinked processes of national and international standardization of time (ca. 1870-1900). Poincaré, who embodied the confluence of theoretical and practical abilities and experience, believed that large technical systems were outcomes of political practice, expertise, and first of all consensus-brokering (Galison 2006, pp. 73-81ff). For others it would make sense to foreground the "social", or rather negotiated, nature of global infrastructures.[31]

Several crucial insights follow from this. To travel in reverse order, we can conclude that diverging national policies matter for the occurrence of innovation processes. First, institutional permissiveness for novelties is important in addition to education and research funding (Acemoglu, Aghion, and Zilibotti 2006). However, governments often fall short of effectively controlling or fostering innovations, which have already been flourished in the hands of inventors, entrepreneurs and companies. The ability of states to shape the cyclic waves of creative destruction and infrastructural advances that made certain populations wealthy, while threatening others with immediate poverty, is limited. Second, technological innovations involve the reconfiguration of particular state ensembles entailing revolutionary impact on society, statehood, and national sovereignty. It is quite reasonable to assume with Sheila Jasanoff (2004b) that a process of mutual "coproduction" of social order, science, and technology works at the core of modern state formation. Hence, theoretical notions and empirical analysis of the "state" which do not feature technologies prominently lack plausibility.

2.4 Controversies about technology, defense, and security

If we accept the co-constitutive nature of technology and political order as a general rule, then the question arises whether military technologies are the exception. As the matter of fact, states have effectively maintained, developed, and used arms appear to contradict the elusiveness of innovations and the non-instrumentalist notion of coproduction. In

[31] This multi-directional change also concerned time consciousness, which predated the rise of industrial capitalism as much as it was its consequence. The project of standardizing time posed an extraordinary organizational and technical challenge and equally it was an enormous social and political struggle, not to mention a profitable business proposal (Sauter 2006, Stenger 1997, pp. 176-211).

other words, this section then investigates whether high-tech weapons contradict the notion of technological dramas because they appear to preserve instrumentalist perspectives. The following may explore a set of puzzles—all situated in the field of high politics—including several techno-political controversies, the often-protracted *indetermination* concerning novel weapon systems, and finally the instable security dynamics in the aftermath of the nuclear revolution.

During the 1930s in many countries, an instrumentalist consensus was under way that might seem implausible in the light of the above discussion. But in a time that brought to life so many (secret) research programs, and especially through the highly symbolic atomic bomb, it was obvious that technological innovativeness, warfare, and security were inseparably interwoven (Krige 2006b, Krige and Barth 2006). [32] Governments appeared to successfully steer innovation processes. For instance, "coming at the tail end of a war in which science-based technology had been crucial", the report *Science—The Endless Frontier*, commissioned by President Franklin D. Roosevelt, called to perpetuate public funding for "basic research". Cementing "government patronage of scientific research in policy discourse", the report successfully promoted the creation of the National Science Foundation in 1950 (Pielke 2010, pp. 922-3).

> "Vannevar Bush, by defining science as a new frontier, played on an historically sensitive chord to persuade the federal government that the patronage of science in peacetime was now its responsibility. The nation's security, health, economic wellbeing, and cultural progress depended on strengthening basic science in academic and research institutions. And what was true for America was true for Europe. Its long-term economic and industrial strength, its political will to stand firm against Communism and to defend democratic institutions and values, and its ability to share in the defense of the West and to contribute to the Atlantic alliance—all these things depended on its having a strong scientific base." (Krige 2006a, p. 256)

[32] It must be briefly remarked here that today's common sense, which takes for granted the innovation-friendliness of militaries, historically is a complete turn-around. Generals and officers have traditionally been reluctant towards inventions and the introduction of novel weapon system. Though wars have sometimes affected technological changes (Nishiyama 2007), if anything, it is safe to say that military leadership were a harbinger of conservatism, avoiding innovations. In a way, this appears to diverge from the historically anti-innovation attitude of armies. Though always not against warfare, generals used to have good reasons to resist novel technologies and were slow in their adaption (cf. Rose 1994).

Offering a ready policy description on both sides of the Cold War technological innovations and science were unanimously perceived and framed as the critical tools in the service of national security (Dickson 1988, Morgenthau 1964). In 1957, the successful Soviet space mission revealed that the US-led nations were technologically lacking behind the communist camp. In immediate response to the surprise launching of Sputnik, the US administration established the National Aeronautics and Space Administration (NASA) and a centralized research agency (today's Defense Advanced Research Projects Agency, DARPA) and quadrupled the annual funding for the national science foundation (Divine 1993).

Consequently, the two super powers were locked into a scientific and technical battle with massive state investments in the build-up of research cities, monitoring systems, and space programs (O'Mara 2004, Dickson 1988). Under the auspices of NATO and various other organizations, the Western alliance put stress on strengthening its scientific base (Krige 2000). The military "dominated the US federal R & D budget" between 1960 and 1990—only three years saw less than 50 percent for this cause (Mowery 1992, p. 136)—while the most cutting edge technologies became central to US war planning, strategy and actual warfare (Adas 2006). The Central Intelligence Agency (CIA) became a stern promoter and developer of the newest technical applications for surveillance, ears dropping, espionage and so forth (Richelson 2001). Military spending, particularly under the umbrella of DARPA, has produced some tangible results. Defense related research in the US gave not only birth to the invention of computer chips, the internet and the following shift to network-centric warfare, but also spurred the scientific and technical race towards virtualization (Der Derian 2009, Singer 2009).

There is more to the role of big science than merely fostering military power projection. "Scientific prowess has become", Paarlberg notes, "the deep foundation of U.S. military hegemony" (Paarlberg 2004, p.122). The turn to ever-larger installations and facilities for "basic research" such as in quantum physics, chemistry, and electronics was a cross-alliance project (Galison and Hevly 1992, Krige 1993). In the form of "scientific internationalism", it has constituted a central transnational element of the "coproduction" of the new consensual American empire after WWII (Miller 2001, Krige 2006a). The restoration and funding of the European research capacities became integral to the Marshall Plan and the US alliance policy towards Europe in the two decades after 1945. "In conjunction with its economic, military, and industrial strength," US scientists tried "to shape the research agendas, the institutions, and the allegiances of scientists in Western Europe in line with U.S. scientific, political, and ideological interests in the region" (Krige 2006a, p. 4). Washington's policies for technology transfer, particularly in the nuclear field, were also marked by attempts to manage competition amongst allies for the most prestigious fruit of modern science. John H. Perkins' study (1997), on the other hand, showed that even the "green revolution", seemingly belonging to "low politics" of agriculture, was as much a result of technological innovation as stemming from the securitization of food supplies during the Cold War.

Remarkably though, one thing has not changed as politicians and generals paid the closest attention towards the ever-evolving industrially and scientifically contrived techniques of warfare: every single new weapon system remained subject to controversy. None of the subsequent "revolutions" in military affairs followed a prescribed, determined pathway. Ambiguity contradicted the instrumentalist underpinnings of official rhetoric and propaganda. The interrelatedness of war, security and technological transformations was never straightforward (Roland 1985). Suffice it to illustrate this with a few prominent examples.

Beginning in the mid-nineteenth century, new transport and communication infrastructures crucial to the second industrial revolution were interconnected with successive revolutions in the practice of warfare and strategic thinking. Communication and transport technologies were among the first. The decisive importance of telegraphic transmission was experienced during the US civil war and the Franco-German war of 1871. In addition, strategists increasingly realized the value of railway lines for fast troop movements and tactical maneuvers (McNeil 1982, van Crefeld 1999). A central observation that has been put forward in retrospect emphasized acceleration: the pace of all activities reaching from public life and travel to industrial production, trade, and warfare rapidly increased (Rosa 2005, Virilio 1980). Kern brilliantly showed in his magisterial study of time and space (1982) how newly introduced technologies have led to enormous changes in the temporal and spatial organization and perception of culture and personal identity.

Victorian thinkers explored the impacts of modern transport systems in terms of geopolitics and imperial governance (Bell 2005). For instance, Halford Mackinder's "Heartland" concept, published in 1904,[33] advanced the idea that the Eurasian landmass determines the future of global power politics. Mackinder famously claimed that a geographically induced power shift was taking place, which came at the expense of sea powers such as Great Britain. He insisted—in line with geologist Alfred Wegener (see Virilio 1980, p. 180)—that international politics should always be analyzed in the context of a single integrated unit, the "World Island". His holistic understanding constitutes a response to the massive shifts he was witness to: England's relative decline, the internationalization of the world economy and the spread of radical new technologies. Writes Mackinder: "Today armies have at their disposal not only the Trans-continental Railway but also the motor-car. They have, too, the aeroplane, which is of a boomerang nature, a weapon of land-power as against sea power. Modern artillery, moreover, is very formidable against ships. In short, a great military power in possession of the Heartland and of Arabia could take easy possession of the crossways of the world at Suez." (Mackinder 1919, p. 80.) Mackinder notices a massive technical "revolution" at work:

> "(The Heartland) has been inaccessible to navigation from the ocean. The opening of it by railways-for it was practically roadless beforehand- and by aeroplane routes in the near future, constitutes a revolution in the relations of men to the larger geographical realities of the world." (Mackinder 1919, p. 55)

The technology-induced "time-space compression" was particularly crucial for his Heartland thesis. Following the inventions of deep-sea cables, telegraphy, radio transmission, the diesel engine, railways and motorcars, scattered places separated by vast spaces and long distance became one entity (O'Tuathail 1992, p. 106, Bell 2005). However, for his critiques Mackinder's grasping of the actual pace and the character of further technological advances was superficial. They laid bare his geographical determinism—keeping the world separated in land and sea power—as conceptually meaningless and empirically outdated (cf. Parker 1982). The competition for trans-oceanic transmission cables and the contested standardization of time and space

[33] Mackinder's thoughts remain influential until today. For recent appreciations of Mackinder's theories see Sloan (1999) and Colin Gray (2004).

measurement between France and Great Britain brought to the fore that global networks of communication and technologies of knowledge gathering were of utmost concern to government activities and imperialistic strategy (Nanni 2012, Innis 2007). Despite this, Mackinder remains a pioneer of globalization who early on realized the extraordinary importance and planetary impacts of new technologies for imperial strategy.[34]

Mackinder's understanding of international politics, that ultimately foregrounds the physical conditions, was quickly substituted by the privileged role subscribed to evolving technologies. Ralph Turner, for instance, claimed that source of the Soviet Union's power is technological progress, which rendered possible massive resource exploitations in Russian hinterlands. Moreover, "the opposition of land power and sea power which conditioned Mackinder's thinking is now greatly reduced for each is entering into a new complex based on air power." (Turner 1943, p. 14) The revolutionary effects of airplanes mark the superiority of technology over other factors—rendering the industrial base and the innovative capabilities paramount. By virtue of this analysis, Mackinder's Heartland thesis was turned into a joke:

> ”Mackinder's attempt to make the horse-riding and camel riding areas decisive for world politics can hardly be made good in an air age." (Turner 1943, p. 15)

But the meaning of "air age", that seemed clear for Turner, turned itself into a major controversy. Already provided in the early history of aviation, many examples of cultural "counterappropriations" then reframed what aviation and aviators stood for (Pfaffenberger 1992a, p. 302).[35] In terms of security, it brought new theories of "strategic bombardments" and a defensive urban posture as the civilian population became prime target for destruction. Already in the late 1930s, the industrial and technological

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[34] Other thinkers followed in emphasizing the nexus between global politics and technological modernization—including, for example, L.S. Wolf, D. Mitrany, or E.H. Carr. Chapter 6 provides a more detailed account; see also Ashworth (2006) and Deudney (2000a, 2000b).

[35] While this diversity pointed to the highly contingent nature of military technology, new technologies that sometimes became entangled into ”symmetrical discourses" in quite different political systems. By the end of the 1930s, automobiles, racing-sports, and car-culture, for example, became inexorably linked to war-preparedness and fighting ability both in the USA and in Germany, which was under the dictatorial rule of National Socialism. On both sides of the Atlantic, the revolution of the transport infrastructure led to mass mobilization through sports and the rise of the automobile society (Virilio 1980, p. 38). This interactive logic that has been advanced by Virilio is at odds with Turner's instrumentalist form of determinism that turns industrial capacities, science, and weapons into ready-to-use tools.

infrastructures moved to the center of strategic war and defense planning (Collier and Lakoff 2008). Metropolitan areas presumably turned into objects of airborne attacks and aerial bombing, so the urban infrastructure and the urban population had to be protected. Long before the Cold War, the safety of civilian populations could only be achieved through the invention of another set of technologies such as gas masks, shelters, bunkers, and warning sirens (Fridlund 2011), while colonized peoples were the first to actually suffer from this new and terrible type of attacks. Airpower played a decisive role for the defeat of both Germany and Japan, leaving no doubts about its centrality for future warfare. Writing shortly before the end of WWII, Liddell Hart stressed that "superior technical appliance" had eliminated other power differentials among nations. The evolution of "automatic warfare" would alter the lethal practice of traditional war into a large-scale "process of destruction," hence, "security has undergone a fundamental change" (cited in Freedman 2003, p. 20). However, airplanes, missiles, fighter jets and strategic bomber fleets have not homogeneously determined strategic behavior. There was no uniform response to this revolution in military affairs (Herrera 2003). As with almost any weapon system, different defense and security practices occurred simultaneously and underwent several reinterpretations and counter-significations.[36] The national reactions to airborne, and by extension long-range missiles, showed a high degree of diversity. Sweden for instance built the world's most extended underground facilities, the US elites sought reassurance from satellite based anti-missile capabilities, while Mao Zedong decided to spread the nation's entire industrial base over the vast Chinese hinterland far removed from US-aircraft carriers (see Naughton 1988).

The final example for the role of indetermination in global techno-politics stirred arguably the longest and most existential controversy about weapons (Herz 2003a). Thermo-nuclear weapons offer an especially intriguing window into the dynamic *mutual* apprehension between technological innovations and material-political interactions. After the bombings of Hiroshima and Nagaski many observers immediately agreed on the revolutionary dimension of this event, although it became clear later that its strategic use was not the main reason for Japan's surrender (Freedman 2003, pp. 18-20). Robert Jervis

[36] Similarly, after the first usage of tanks more than 20 years passed by until World War II for this novel weapon to become properly integrated into battlefield tactics and war strategy (McNeil 1982, p. 333).

(1989) among others has argued that the "nuclear revolution" had fundamentally altered statecraft and war. It led to a "radical transformation in the nature and distribution of power" (Williams 1986, p. 298). The outcome of this revolution was real and yet clumsy at the same time. Ultimately, the Bomb did open the gate to complete annihilation, but has not eliminated politics: as Francis Gavin (2012) forcefully argues, nuclear warheads did not simply determine defense policies and shape military strategies. So, whether atomic weapons have reshaped the international system according to their own image, and whether the potential of nuclear proliferation is welcome or worrisome, remain widely open practical and theoretical issues (Freedman 2000).

At the beginning of nuclear politics, social movements and numerous prominent individuals including Albert Einstein and Albert Schweitzer kept forcefully contesting nuclear weapons. Their priority was not just a taboo, but abandoning this technology on moral grounds (Wittner 1993). Einstein, for instance, deeply regretted his involvement in the birth of the atomic weapon research program, the secret Manhattan Project, and became the first chairman of the "Emergency Committee of Atomic Scientists, Inc." that was dedicated to close the Pandora's Box of the nuclear bomb (Rife 2005). The Bomb, Einstein believed, was a radically novel situation that demanded immediate adaptation of human thinking because humanity "shrunk into one community with a common fate". Ordinary people, according to Einstein "behold the ghostly tragic-comedy which is being performed on the international stage before the eyes and ears of the world. But on that stage, on which the actors under the floodlights play their ordained parts, our fate of tomorrow, life or death of the nations, is being decided" (Rife 2005, p. 6). In November 1946, Einstein summarized his account of a terrible socio-technical dilemma:

> "…the position in which we are now is a very strange one which in general political life never happened. Namely, the thing that I refer to is this: To have security against atomic bombs and against the other biological weapons, we have to prevent war, for if we cannot prevent war every nation will use every means that is at their disposal; and in spite of all promises they make, they will do it. At the same time, so long as war is not prevented, all the governments of the nations have to prepare for war, and if you have to prepare for war, then you are in a state where you cannot abolish war." (Letter by A. Einstein, cited in Rife 2005, p. 7)

Similar to Einstein, John Herz's *International Politics in the Atomic Age* (1959) replaced the narrow focus on national security with the existential danger of planetary annihilation. He advised universalist policies that should (and must) ultimately overcome the security dilemma. But first of all, the life-and-death challenge of the nuclear arsenals required, according to Herz, a radical change of mind-sets all around the world, for humanity's survival was at stake (Hacke and Puglierin 2007, pp. 374-377). Morgenthau and Herz were convinced of "the obsolescence of the state-system on a global scale and the need for a world state" (Deudney, 2000b, p. 21). In short, "nuclear one-worldism" was a common strand in early IR thinking.

The Christian-realist philosopher Reinhold Niebuhr, another astute US commentator during the onset of the atomic age, wrote in a less existential language. He understood the "Bomb" first of all as an irony of history that illustrated the fallacy of modern enlightenment thought, thought that championed technological progress and scientific mastery of nature. Once put into the world, the Bomb could not be hidden, stopped from spreading or undone. In his realist understanding it was impossible to escape from this "nuclear dilemma". Hence he opposed all kinds of "utopian" solutions advanced during the 1940s and 1950s such as schemes of world government, mutual disarmament, or the West's unconditional capitulation. According to Niebuhr, the possibility of mutual annihilation led to a "balance of terror" (William 1986, p. 300).

However, it was not just the forces of particle physics forced statesmen into a precarious peace based on mutual deterrence. Neither did scientific advice simply determine policy. The story is far more complex and rife with controversies (Gilpin 1962) as the "political-military effects of a new technological device" involve a mix of uncertainties about the future, common sense, philosophical considerations, and political interests (Morgenthau 1964). A paradoxical double movement arose from this delicate and first phase of "management" of the Bomb. On the one side, after a period of active planning of nuclear war fighting, nuclear bombs increasingly fell under a taboo that stigmatized the use of "weapons of mass destruction" (Tannenwald 2007). On the other side, the growing nuclear arsenals posed the constant threat of destabilization while "deterrence" was only a theoretical idea and heavily contested at that time (Gaddis 1997, Gavin 2012). In the midst of a technological arms race in the wake of the Sputnik shock strategists, politicians, and generals were in the mood of "assigning to technology a predominantly disruptive role" (Freedman 2003, p. 160).

Already at the dawn of the atomic age, Niebuhr had repeatedly stressed the need for both unwavering attention and cautious restraint because of the real possibility that the handling of nuclear weapons could quickly spiral out of control. He criticized Einstein's retrospect "defeatist" stance on grounds that, against "liberal sentiments", men but have to face the unavoidable moral ambiguities of the nuclear age. Given the anarchic circumstances, he rejected a world governance as advocated for instance by Einstein (Williams 1986, p. 295). Likewise, he condemned Henry Kissinger's idea, who in 1957 promoted using tactical bombs in combat because for him a blurring of lines between "tactical" and "strategic" weapons seemed technically unavoidable (Williams 1986, p. 302).

Others were concerned with the unintended domestic consequences of certain technological choices, particularly the alleged authoritarian ramifications of nuclear power. Jungk and Winner enlarged the debated terrain in resistance against what they saw as a reshaping of liberal societies, civil law, and democratic institutions under the veil of techno-political necessities (Jungk 1952, 1977, Winner 1977). In addition, to respond to increasing wariness of many allies and the elites in block free states, President Eisenhower advanced the "Atoms for Peace initiative" at the United Nations in December 1953. The sharing of civilian usage of nuclear energy should provide legitimacy for the nuclear dominance of the US (Krige 2006b). In short, nuclear politics were anything but stable. Only after the mid-1960s, the contradictive policy discourses about the bomb slowly converged and became stably organized by the concepts of arms control and deterrence. The notion of "interdependence" that opened the possibility of cooperation become stabilized by the confluence of ideas within epistemic communities and developments in game theory and modeling. Ultimately, this preliminary closure of the main controversies was reached at the expense of ideas such as military superiority or disarmament (Adler 1992, Gavin 2012, pp. 120-128).

While the understanding of deterrence became the mainstream, the bomb—in the public and within the strategic community—was rendered into a mere tool subject to incremental control and technical management (Bourne 2012, p. 150). As such a form of "nuclear mechanics", Kenneth Waltz's classical formulation (1981) is suggestive for the framing on which grounds the debate of the 1940s and 1950s came to a closure. Describing the time-tested reliability of deterrence dynamics and the stability they provide in a bipolar system, Waltz denies serious concerns about the manageability of the nuclear arsenal. Instead, rooted in his state-centered worldview, he claims spreading the Bomb would stabilize international affairs; the Bomb as positive force that presumably mitigates wars, aggression, and arms races.

> "Nuclear weapons in the hands of six or seven states have lessened wars and limited conflicts. The further spread of nuclear weapons can be expected to widen those effects. Should the United States then promote the spread of nuclear weapons for the sake of peace, even though we need not for the sake of stability? To do so would replace one extreme policy with another. Present policy works hard to prevent additional states from acquiring nuclear weapons. My examination of the effects of nuclear weapons leads to the conclusion that our policy is wrong without supporting the proposition that true proliferation—the rapid spread of nuclear weaponry—is desirable. Rapid change may be destabilizing. The slow spread of nuclear weapons gives states time to learn to live with them, to appreciate their virtues, and to understand the limits they place on behaviour. (…) Nuclear weaponry makes miscalculation difficult because it is hard not to be aware of how much damage a small number of warheads can do." (Waltz 1981/2008, p. 418)

The undisturbed language of rationality, which is marked in this passage, reflected the factual self-restraint of the nuclear powers after the late 1960s. But the tentative stabilization of the nuclear terror has more origins, and is more delicate, than this seemingly crystal-clear logic of deterrence would permit. First of all, what deterrence exactly meant was subject to intense debates (Freedman 2004, Gavin 2012). Furthermore, concerning nuclear weapons, "deterrence" was not the only game in town that led to "cold peace". First of all, the messy *industrial-tactical-technical-political* reality of Cold War "strategies" produced their own tensions and rapprochements. Numerous studies showed the complex interplay of thermonuclear stockpiles, missiles systems, bureaucratic capabilities, civilian expertise and surveillance systems, nuclear energy usage, and military doctrine (MacKenzie 1984b, Ritchie 2010, Krige 2006b, Hecht 2010).

> "In understanding why the nuclear world has been configured in this way, it is tempting to reach for a simple, single, comprehensive cause—the aggressive tendencies of imperialism, say, or the 'inertial thrust' of exterminism. There are strengths in such explanations. But analytically they fail to grasp the sense in which our nuclear world is a layered, a contested and often an inconsistent outcome. Nuclear militarism is not a rational, functional prerequisite of a socio-economic system; nor is it an irrational, technologically-determined Behemoth. It occupies an uneasy, difficult-to-specify, theoretical middle-ground of partial, local nationalities, and of organisational and political conflict. It is shaped more by the exigencies of politics than by those of technology; but that does not imply it is a coherent, rational creation, even of an evil ruling elite." (MacKenzie 1984b, p. 45)

Paul Virilio, writing in the late 1970s, similarly doubted the convenient simplicity of the logic of mutual deterrence or mutually assured destruction. The powerful elegance of Waltz's argument concealed a thorny issue. To make no mistake, Waltz would not have denied the complexity of nuclear weapons but he, like generations of experts, foregrounded the notion of cost-benefit calculations in his final analysis (see Sagan, Waltz, and Betts 2007). Virilio, in contrast, stressing how evolving technological conditions render the security situation increasingly instable, saw the preconditions of deterrence in constant need of reproduction. Both sides, he explained, were locked in a race to improve their weapon systems. But the trajectory of technologies, the increasing speed of missile attacks, inevitably turns the pursuit of national security into a "war over time" (Virilio 1980, p. 184). As a consequence, successive arms-control negotiations faced the increasing difficulties of keeping the practice of deterrence possible in the first place.[37] Washington and Moscow had no choices but to limit the sophistication and abilities of their arsenals collectively through a mutual consent in order to maintain the actual times-span for alerts and decision-making over counter-attacks reasonable, This was for a reason that, reducing reaction time to minutes or seconds would have meant to concede any serious choice to a computer system, which was also something the US and Soviet leadership wanted to avoid under all circumstances (Virilio 1980). Today, the intricacies of nuclear arsenal still shape bilateral interactions between the US and Russia,

[37] For more on this point see Chapter 3, section 3.5.

although the end of the West-East confrontation rendered the threat that legitimized the practice of mutual deterrence obsolete (Pouliot 2010, p. 301).

The controversy about the potential abolition of nuclear weapons has also reappeared. A group of elder statesmen around former Secretary of State Henry Kissinger started a new wave of public debate in January 2007.[38] They called to abandon nuclear weapons entirely, proclaiming a "vision of a world free of nuclear weapons" in the *Wall Street Journal*. With positive response in the global media and support from other politicians, the four men—dubbed the "four horsemen"—rendered the nature and consequences of the Bomb and its possible proliferation or abolition once again a matter of contestation (see Schelling 2009). Ironically, to demand a complete abolishment of the "Bomb" was something the very same individuals had earlier perceived as an absurdity—Kissinger even calling for use of tactical warheads during the 1950s. By now the "four horsemen" do consider this utopian vision, which was rejected by Niebuhr some fifty years ago, as "consistent with America's moral heritage" (Shultz, Perry, Kissinger, and Nunn 2008).

> "The accelerating spread of nuclear weapons, nuclear know-how and nuclear material has brought us to a nuclear tipping point. We face a very real possibility that the deadliest weapons ever invented could fall into dangerous hands. The steps we are taking now to address these threats are not adequate to the danger. With nuclear weapons more widely available, deterrence is decreasingly effective and increasingly hazardous." (Shultz, Perry, Kissinger, and Nunn 2008)

What worries the "horsemen" is not only the potential breakdown of deterrence. If the bomb gets into the hands of a rogue regime or terrorist groups, these are not expected to behave rationally. What is really at stake is the practical handling of the material complexities of the nuclear arsenal *per se*. Human control over this technology *in general* appears highly precarious and unreliable. This indicates again that an awful lot of more things are going on than in Waltz's clean world of atomic rationalization. In short, the handling of nuclear weapons is so messy and slippery that its dangers are intolerable even

[38] It also was in the midst of a heated anti-Iran media campaign in the US that complicated already difficult negotiations between the IAEO and Teheran about an alleged nuclear weapons program (Al Baradai 2011). In this regard, Kenneth Waltz has not changed his opinion one inch when undeviatingly praising the option of a nuclear-equipped Iran (cf. Sagan, Waltz, Betts 2007).

under the guard of US Air Force specialists. "'Mistakes are made in every other human endeavor. Why could nuclear weapons be exempt?' To underline the governor's point, on Aug. 29-30, 2007, six cruise missiles armed with nuclear warheads were loaded on a U.S. Air Force plane, flown across the country and unloaded. For 36 hours, no one knew where the warheads were, or even that they were missing." (Shultz, Perry, Kissinger, and Nunn 2008)

In sum, a similar pattern may characterize examples of new weapon technologies spanning from the nineteenth to the twentieth century: practitioners and theoreticians had great difficulties to comprehend the nature, causes, and consequences of technological innovations upon modes of strategy and security practices. Some such as nuclear weapons remain essentially contested. Even controversies, which had long been settled, can open up again to renew a technological drama. The introduction of new technologies, if anything, makes it increasingly difficult for military commands to distinguish between war and peace. So while determinist accounts fell short of providing a convincing picture, social reductionist explanations likewise are flawed. The innovations in weaponry, for example, have not caused and often not even conditioned certain forms of warfare. They were not unmoved movers, yet have shaped security practices and strategic responses in a process of coproduction. What we find are shifting and unstable entanglements into various social practices and discourses. As a consequence, we should treat controversies about weapon systems as an integral part of the effects of technological innovations on power and security, instead of searching for unidirectional determination or abstract causation.

2.5 Summary

Framing technological innovation as drama may provide a good starting point for the conceptualization of global techno-politics. Our exploration of the evolution of multiple technologies speaks to John Law's assertions cited at the beginning of this chapter. Determinist and social reductionist approaches are conceptual problematic because they share a dualist ontology incapable of accommodating to the transformative power, ambivalence, and unpredictability of innovations. To recognize that the social and technical realms are constantly blurring is not sufficient. These two domains seem to have never really been separated in the first place (Law 1991, Mitchell 2002).

What general lessons can we condense from these puzzles as detailed in section 2.2, 2.3 and 2.4? Firstly, technological innovations are significant for global politics in particular ways that both technological determinism and social constructivism cannot comprehend. The puzzle of the “great divergence” for instance illustrates the process-character and long-term consequences of innovations. Their effects are characterized by complex interrelations, feedback loops, and diffusion dynamics that are at the same time technical, political, commercial and cultural. Secondly, the difficulties of states have been showed in managing, guiding or fostering new innovations. Apparently, statesmen, bureaucrats, and scholars have dealt with paradoxical challenges ever since the onset of modern statehood, while states possess only limited control over innovation activities. Finally, the ability of governments to predict how certain technological innovations change warfare and security, especially with respect to the most destructive weapon systems, is almost inexistent—not to mention the incapability to control weapons systems effectively from evaporating.

3. Classical theorists beyond the instrumentalist-determinist divide (interlude I)

Moving beyond the idea of "technological dramas" introduced in Chapter 2, this chapter takes a detour to inquire into research designs and theoretical vocabulary of classical theorists that have tried to avoid static and dualist biases. In particular, while the works of Karl Marx, Joseph Schumpeter and Harold Innis are zoomed into, I would come back to the conceptual roadblocks of instrumentalism and determinism to seek for a more appropriate approach. Chapter 2 discussed three puzzles related to technological innovations, showing that they evolve at the intersection of social, political, technical dynamics. Subsequently, this interlude offers another perspective and interrogates three interrelated methodological issues—the unit of analysis, the characteristics of process, and the distribution of agency—that are worth considering if we want to develop a better theoretical grasp of the problem at hand.

3.1 Determinism and the unit of analysis

Scholars have construed different spatial demarcations and principle actors in their studies of technological innovations. The emphasis here, instead of asking how empirical observations or data can be utilized to theorize, is to revisit the nexus between these conceptual abstractions and determinist frameworks; especially, concerning the "unit of analysis". My thesis is that the unit we select as the focus of our inquiry and subsequent explanations often implies certain types and directions of determinism to which we have to tackle subsequently. This point is exemplified by Max Weber's critical commentary on Marx's determinism:

> "in Marx (…) that oft-quoted passage (…) is contradictory: the hand-mill causes feudalism, the steam-mill causes capitalism. (…) This is not an economic, but rather a technological construction of history; and that it is simply wrong is indisputable from the claim itself. This is because the era of the hand-mill, which reaches to the threshold of the modern age, has seen every conceivable kind of cultural 'superstructure' in all fields. (…) The same technology does not always denote the same economy, nor is the reverse always the case. (…) In Antiquity there was above all a capitalist development which can be measured against any other capitalist development in the world. But the capitalist development of Antiquity started the ascent – and I'd like to emphasize this here while exaggerating a bit –

> to its highest peak at that moment when, according to our knowledge today, the technical development of Antiquity was at an end. (…) Capitalist development today apparently goes hand in hand with technological development, so much so that technicians have seriously come to believe that technology and its evolution may be the exclusive leading element in our cultural development." (Weber 2005, pp. 26-28)

One can, of course, agree with Weber's refutation of "hard" determinism albeit his treatment does not do justice to the nuanced modes of "productive determinism" that Marx developed throughout his works. Weber (2005, p. 28) is equally correct when he, continuing his argument, rejects the opposite extreme of a purely human/social determination of machines. However, the critical aspect I want to point out is that the viewpoints of both Weber and his opponents are animated by a similar historical macro-narrative. They advanced large units of analysis such as "civilization", "capitalism" or "society" combined with abstract levels of generalization. There is no coincidence that macro-sociological framing would lend itself more readily to technical determinist views than micro-level analysis (Misa 1994, p. 141). The reason that they tend to over-simplify technologies is because these perspectives boil down highly complex matters into the juxtaposition of a technical world of machines on the one side and human collective activities on the other.

Furthermore, the grammar of the related macro-level language may easily lead to dystopian or pessimist (for others triumphant, cf. Berman 2010, p. 25ff) opinions about future developments. The critiques of modernity are often driven by a fear of the unstoppable force of machines overwhelming the fragile social fabric. In macro schemes there is no place for a differentiated determinism that highlights varying institutional responses to the effects of machines and infrastructures (e.g. Heilbronner 1994, Winner 1986). The "big picture" view prevails. Generations of philosophers and theorists trumpeted the fanfare against the techno-titans that, as many believed, undermined democratic/liberal institutions and ultimately were bound to enslave humankind (Feenberg 1991).[39] Against the machine culture of Enlightenment, Horkheimer and Adorno (1997, p. 25), for instance, lament that "thinking becomes an automatic, self-

[39] Authors writing in this tradition include Ellul (1964), Mumford (1966), Heidegger (1977), Postman (1992), Watson (1997), and Luke (1994).

activating process; an impersonation of the machine that it produces itself so that ultimately the machine can replace it." Three Canada-based technology theorists have then developed a similarly critical understanding of modern technologies. In the view of Harold Innis, Marshall McLuhan, and George Grant,

> "one finds practice-based understandings of technology, which emphasize the danger that technology poses to our civilization. Over the course of their careers each of these three thinkers also argued that our ordinary involvement in technological practice can create a dependence on a technological approach and that meeting the ethical challenges of technology must involve an appropriate awareness of this kind of dependence." (Gerrie 2007)

While these concerns have not ceased to exist, recent research advanced much more fine-grained approaches to technology. Historians are at pains to avoid the opposition of abstract binary notions. In addition, their description of change in a technologically mediated world does not imply a process of "hybridization" of separated domains such as suggested by terms like "socio-technical" or "society-nature". Instead they uncover that, though in diverging manners, there had never been a separation in the first place (MacKenzie 2006, Carroll 2006, Thrift 1996). This task is difficult since it tends, as we have seen, to defy conventional language and conventional wisdom.

Peter Galison, for example, introduced the notion of "critical opalescence" in order to describe the historical "emergence" of the idea of relativity (Galison 2006). By using this conceptual metaphor, he highlighted the "triple intersection of practical, abstract, and philosophical issues" (Yerxa 2003, p. 6). Critical opalescence neatly corresponded with the idea of a "seamless web" that Thomas Hughes regarded it so characteristic for technological systems (Hughes 1986). This approach is the radical opposite of macro-sociology for Galison urged to dissolve the dichotomies, which are often mapped upon modernization. Remaining somewhere in an explanatory no man's land, he did not allow for a single primary reason that explained the emergence of relativist thinking in physics (and beyond). It is neither technically, nor socially, nor philosophically determined.

> "There isn't one scale at which this story is grounded or founded. There isn't an originary or fundamental scale. It is all at once about philosophy, technology, and physics. And the fluctuations of scale between the abstract ideas of conventionalism and a new kind of

knowledge and the practical exigencies of wiring up continents so that they'll tell the same time are very rapid and an essential aspect of this story. Is this a story of social history? Yes. Look at the coordination of cities, trains, markets, and maps. Is this a story about the intellectual history of physics? Yes. Relativity is one of the epochal changes in the discipline. Is this a question about the history of philosophy? Again, yes. Conventionalism reshaped modern philosophy." (Galison cited in Yerxa 2003)

The first move that Galison emphatically stressed is not to discriminate between social, scientific, and technical contexts. His stance indicated a strong form of anti-foundationalism that challenges both logocentrism and determinism. Whereas Galison (2006) noted that the conditions of critical opalescent are exceptional rather than the norm, the puzzles presented in Chapter 2 indicated that his notion is carried upon the politics of technological innovations in general (cf. de Laet, and Annemarie Mol 2000, Law 2002). It is in this sense that we have to look for conceptual frames that mirror fluid, hybrid, interconnected worlds, concepts that nevertheless offer a well-tailored unit of analysis. From Galison's analytical perspective, classical IR units like the state, the international system and so on have limited use, because applying "methodological nationalism" to the exploration of technological innovations would inevitably lead to paradox puzzles. Yet Galison's solution to simply abstain from a clearly shaped unit of analysis is not so satisfying, the notorious oppositions of empty signifiers such as "state" vs. "technology" are similarly the misleading. Neither does the idea of "hybridization" suffice if it means adding up previously separate domains in order to regain the conditions of possibility for "parsimonious" theoretical puzzles.

So, while macro and micro framings do not offer a way forward, there are middle-sized approaches to theorize technological innovations that seem most apt. For instance, Braudel's (1992c) "world-economies" and Jasanoff's (2004a) "coproduction of order" provide an alternative vision how we might shape the unit of analysis. At closer inspection, however, the scope of these notions is still too encompassing and they (deliberately) remain underspecified in analytical and conceptual terms.[40] They

[40] Braudel's structural historiography explores the interplay of technological shifts and the social, economic and political (Arrighi 2001). Yet, his somewhat organic unit "world economy" is by and large physically and not technologically determined (see Kinser 1981, pp. 77ff, 91ff, and p. 103). "Coproduction" does in a different sense not suit our purpose. Jasanoff's idea of coproduction is not intrinsically linked to a particular

nonetheless have great value as metaphysical umbrella concepts, which could supplement mid-range approaches (see Jasanoff 2004b, pp. 19ff).

social reductionism	the 'social' cultural, economic, political, subjective, normative factors or activities	*Determines, shapes, enables, utilizes, signifies, or constrains* $\longrightarrow$	'technology' machines, techniques, infrastructure, tools, networks, systems
technological determinism	the 'social'	*Determines, shapes, enables, or constrains* $\longleftarrow$	'technology'
heterogeneous approaches	environment	*Interaction co-constitution co-production* $\longleftarrow \quad \longrightarrow$ $\longrightarrow \subseteq \; \supseteq \longleftarrow$ $\longleftarrow \quad \longrightarrow$	environment

TABLE 3.1 CONCEPTUAL APPROACHES TO TECHNOLOGICAL INNOVATION ©AUTHOR

The most promising "scope" for the unit of analysis seems to be the middle-sized notions that have been advanced by STS scholars. To name just a few: "technological system" (Hughes 1994), "sociotechnical systems" (Fox 1995), "heterogeneous networks", "actor-networks", "collectives", or "assemblages" (Latour, Callon, Law), "technological zones" (Barry 2006), and "sociotechnical ensembles" (Bijker 1993).[41] Without going into much detail at this point their advantages are obvious. They are heterogeneous in the sense that they assume (in different variations) the confluence of social and technical aspects into a single reality. Furthermore, these conceptual approaches confine the unit of analysis to a tangible, hybrid entity delimited in time and spatial extension. In turn, these authors

unit or level of analytical perspective. It has indeed been used among other things to analyze "global-local" puzzles. Its flexibility can be seen as strength.

[41] See for early collections of these approaches MacKenzie and Wajcman (1985), Bijker, Pinch, and Hughes (1987), Bijker and Law (1992) and Law (1991a).

assume their units to be surrounded by a distinguishable environment while both have mutual effects on each other. The conceptual move of heterogeneous approaches has a dual strength. For one, it is widely tested by diverse empirical case studies that avoid social reductionism. For another, it promises to replace determinism of all sorts with a fine-tuned research framework based on notions of interaction, co-constitution, or coproduction (see table 3.1).

3.2 Levels and concepts of process

Having outlined the advantages of heterogeneous middle-range approaches, the next step is to apprehend the dynamic characteristics of technological innovations without resorting to linear, mechanistic program or narrative. As we have learned, innovations do not follow a predetermined script. Blueprints do not exist. Their evolution rather contains unpredictable interactions between social, ideational, and technical elements that are often shifting from one level to another. Acknowledging these twists we cannot but reject the assumption that technological innovations emerge out of the blue, implicitly built in the premises of various models and theories.[42]

In principle, innovations all have to enter a co-productive phase including controversies and reconstruction, in order to get accepted and smoothly functioning in all their technical, political, economical, and social dimensions and relationships. Considerable time has to be taken until technological artifacts turn into what Bruno Latour called "black boxes" (2005)—achieving the stable, irreversible, "hard-core" character of a matter of fact. Here raised the question: as technologies have a drama-like history of "stabilization," what would conceptual frameworks suit capturing the relevantly revolutionary changes? For an answer it is worth comparing the strengths and shortcomings of the models of technological dynamics that three famous social theorists have advanced. How have Marx, Schumpeter, and Innis theorized the process that we label here as "coproduction"?

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[42] For a comprehensive overview about different explicit models of technological change see Parayil (1999).

Karl Marx understood the societal change as structurally determined by way of contradictions between the superstructure, the relations of production, and the material forces of production (Tilley 1982, p. 35). The introduction, for example, of new machines which via industrial automation that helped reshaping the modes of production, is indicative of "the instrumental use of technology by the bourgeoisie for their own ends (…) in the capitalist phase of history. Technology neither causes nor necessitates the class struggle that follows." (Bimber 1994, p. 96) If machines primarily *serve* interests, the specific history of innovations has no conceptual weight. Innovations and innovators, thus, have historic significance only in the sense as they reinforce processes of economic accumulation and psychological struggles of alienation (Bimber 1994, p. 97). In Marx's view, technical achievements such as newspapers and railways undermine social order elsewhere in the world:

> "when you have once introduced machinery into the locomotion of a country, which possesses iron and coal, you are unable to withhold it from its fabrication. You cannot maintain a net of railways over an immense country without introducing all those industrial processes necessary to meet the immediate and current wants of railway locomotion and out of which there must grow the application machinery to those branches of industry not immediately connected with railways. The railway system will therefore become, in India, truly the forerunner of modern industry." (Marx 1853, p. 37 cited in Adas 1990, p. 240)

The automatic flavor of this structural understanding of the processes of production and commerce is not confined to Marx alone. Contemporary observers likewise understood the technological progress as the step towards the opening up and regeneration of Asian societies. This viewpoint placed technological innovation at the center of a broader process of market expansion and transformation that would bring to the fore new modes of societal organization and class cleavages (Adas 1990, p. 239, 241). And yet, as Nick Dyer-Witheford emphasized, Marx's commentaries and descriptions concerning nineteenth-century technologies have sprinkled over his encyclopedic oeuvre and, taken together, been allowing for a nuanced and contextualized reading of technological revolutions.[43] On the one hand, he saw the explosive growth of technologies such as

[43] Marx's historical materialism changed over time. Particularly seen in his early and late works, which offer different readings. Marx is anything but a "technological determinist" as his understanding of the

railways, telegraphy, and steamships "as tendrils for the extension of a system of domination (…) and the 'automization of the world market'" (Dyer-Witheford 1999, p.41). On the other hand, Marx valued their "liberatory possibilities" because these technologies tended to undermine "parochialism, localism, and narrow national interests" while functioning as "potential catalysts for proletarian internationalism." (Dyer-Witheford 1999, p. 42)

In sum, Marx's understanding of machinery and travel and telecommunications technologies "oscillated" between to rival possibilities. At one pole, technology is an instrument of capitalist domination, a means for the intensification of exploitation and the enchaining of the world in commodity exchange. At the other, it is the basis for the freedom from want and the social intercourse that are the prerequisites for a communist society. How much emphasis is given to each pole, and by what logic or narrative they are connected, is, however, a matter of huge contention." (Dyer-Witheford 1999, p. 42, Matthewman 2011, pp. 29-49) This structural bipolar view has another consequence: it would downplay the role of actors such as entrepreneurs, merchants, workers or inventors during an age of bustling entrepreneurial activity. It stemmed from an influential intellectual tradition handed down from Smith and Ricardo, theorists who had systematically downplayed entrepreneurial activities. Readers of their works are "bound to get an impression", as Schumpeter noted, "to the effect that this process runs on itself." (Schumpeter 1949/2008, p. 255)

Joseph A. Schumpeter, in contrast to Marx's structural view, stressed the actor-centric dynamics of economic development, which are associated with the concept of "creative response". For him, "entrepreneur-heroes" would carry out a historical mission in the context of "creative destruction" (Witt 1992, p. 219). According to this process model, entrepreneurs may realize something that is "outside of the range of existing practice" and thereby create fundamental discontinuities in the economy. This could

connection between technologies and social change is much more differentiated than many critiques admit. In Marx's writings, technologies figure differently depending on different historical periods. As they are aligned to labor relations, social resistance against alienation and exploitation, they are first of all enablers of the bourgeoisie's profit interests (see MacKenzie 1984a, Moore 1975, p. 181ff.). Technology, accordingly, is not the sole driving agent. Societal configurations have rather changed in concert of technical, social, financial, and psychological conditions (Bimber 1994).

involve anything from the introduction of new products over the establishment of a new market to the exploitation of new resources and lands or the creation of novel categories of commodities. As such, the transformative effects of creative entrepreneurial efforts, which on average have more often failed than succeeded, are irreducible. They resemble, as Schumpeter reassured us, "an essential element in the historical process" (Schumpeter 1947, p. 222).

At the one hand, the purposeful use of technologies is instrumental for this process. On the other hand, Schumpeter perceived technological progress at a larger level as inevitable, infinite, and (almost) unstoppable evolution. For example, he rejected the assumption that the geographical exploration and utilization of the entire globe—an insight that has already stipulated Mackinder's heartland theory—could progressively diminish investment opportunities and, ultimately, bring an end to 150 years of capitalist growth. Schumpeter not only anticipated the Club of Rom predictions of the 1970s concerning limited planetary resources but also refuted its core argument. According to him, "technological progress effectively turned the tables on any such tendency." Because of technological innovations, "it is one of the safest predictions that in the calculable future we shall live in an *embarras de richesse* of both foodstuffs and raw materials" (Schumpeter 1947, p. 117).

Moreover, as Schumpeter was the first economist to rigorously theorize economic development as cycles, technological innovations became conceptually related to macro shifts and pattern of the global economy (Arrighi 1994).

> "An analogous argument applies to the widely accepted view that the great stride in technological advance has been made and that but minor achievements remain. So far as this view does not merely render the impressions conceived from the state of things during and after the world crisis—when an apparent absence of novel propositions of the first magnitude was part of the familiar pattern of any great depression—it exemplifies still better than did the "closing of humanity's frontier" that error in interpretation economists are so prone to commit. We are just now in the downgrade of a wave of enterprise that created the electrical power plant, the electrical industry, the electrified farm and home and the motorcar. We find all that very marvelous, and we cannot for our lives see where opportunities of comparable importance are to come from. As a matter of fact however, the

> promise held out by the chemical industry alone is much greater than what it was possible to anticipate in, say, 1880, not to mention the fact that the mere utilization of the achievement of the age of electricity and the production of modern homes for the masses would suffice to provide investment opportunities for quite a time to come" (Schumpeter 1947, pp. 177-118).

In Schumpeter's systemic view, technology-induced waves of destruction would result in the predictable occurrence of up-and-down cycles. This led him to qualify Marx's historical materialism. While a down-cycle does not mean the end of capitalism, the innovations do not reinforce a fixed path or teleological processes of accumulation and concentration, either. They are rather successive singular events that set in motion an evolutionary dynamic of economic development (Schumpeter 1947, 1934). At the heart of this process lie the power of novelty that might even transcend "land" and "labor" as the traditional resource bases of economic activities. As Schumpeter maintained, "the conquest of the air may well be more important than the conquest of India was" (Schumpeter 1947, p. 117). Ultimately, no "frontiers" can impede this infinite process. Writes Schumpeter:

> Technological possibilities are an uncharted sea. We may survey a geographical region and appraise, though only with reference to a given technique of agricultural production, the relative fertility of individual plots. Given that technique and disregarding its possible future developments, we may then imagine (though this would be wrong historically) that the best plots are first taken into cultivation, after them the next best ones and so on. At any given time during this process it is only relatively inferior plots that remain to be exploited in the future. But we cannot reason in this fashion about the future possibilities of technological advance. From the fact that some of them have been exploited before others, it cannot be inferred that the former were more productive than the latter. And those that are still in the lap of the gods may be more or less productive than any that have thus far come within our range of observation." (Schumpeter 2003, pp. 117-118)

Schumpeter's and Marx's accounts of the politics of technological innovations contain a precious heritage. While both contextualize technological innovations within the global political economy, suggesting different structural pattern, Schumpeter emphasized the micro component of entrepreneurial activity related to innovations. Thus theorizing processes, both theorists also pointed to ways in which agency can be conceptualized.

3.3 The material and distributions of agency

While unfolding at the personal level between machines and the laborers, Marx's version of the technological drama has cumulated in mutually reinforcing macro processes of automation, alienation, and accumulation. In the Marxist sequential scheme of history, these processes and struggles are embedded in the dialectics of historical materialism. Here, the individual agency is of secondary importance and different technologies are in themselves not significant. Schumpeter's version of technological dramas, on contrary to Marx's, is bound to the agency of a specific group, the entrepreneurs many of whom display an instrumental perspective on technologies. Yet, at the same time, the realization of technological novelties has led to an infinite number of revolutionizing events. These remade economic structures, creating new products, processes, markets, and entire economies. Schumpeter has then coined this historical progress "creative destruction". It included more diverse aspects than Marx's model of historically structured dialectics of class struggle. Most importantly, it replaced a dialectical understanding of history with a contingent one. Apparently, comparing these positions would thus take one more or less to the opposite ends of the classical structure-agency duality. But such a reading would have missed out the subtleness and richness of their descriptions. Clearly, these scholars were struggling with the nature of technological dramas. But with all their limitations, neither did they articulate a simplistic determinism, nor did they pursue social reductionism.

On a conceptual level, however, one could still detect an under-emphasizing of the agential power of technologies. For Marx and Schumpeter deem the latter either as carriers of the structural dialectics or as tools for heroic entrepreneurial agency. On the one side, Marx took for granted interest-driven implementation of new techniques and machineries somewhat as innovations *deus ex machina*, shaping social-technical changes. On the other side, Schumpeter stressed the immense difficulties that actors have to overcome prior to stabilizing innovations. The resulting monopolization practices and shifts in economic structures are seen first of all as an issue of investment opportunities and economic wealth creation. Both accounts definitely have not exhausted the potential to comprehend *the back and forth within varying socio-technical entanglements*.[44]

Another point was the concerns on the spatial limitations of the conceptual lenses at their disposal. Marx and Schumpeter were not specifically sensitive to the interactive role of geography and time in mapping differing transformative features of innovative dynamics. The idea that territories and environments could in certain ways interact with technological innovations, and thereby possess a form of agential power, was not of their concern. It is Harold A. Innis' work on communication that could provide us with this insight. Innis' "medium theory" proposed to focus on communication environments "as part of the structural-material landscapes in which human being interact." (Deibert 2002, p. 117) His main concern is how historically changing media technologies differently constrain and facilitate the effective governance of empires.

> "The concepts of time and space reflect the significance of media to civilization. Media that emphasize time are those that are durable in character, such as parchment, clay, and stone. The heavy materials are suited to the development of architecture and sculpture. Media that emphasize space are apt to be less durable and light in character, such as papyrus and paper. The latter are suited to wide areas in administration and trade. (…) Materials that emphasize time favour decentralization and hierarchical types of institutions, while those that emphasize space favour centralization and systems of government less hierarchical in character." (Innis 2007, p. 26-27)

Far from being overly deterministic, his conceptual understanding is sensible to historical contexts of technological change (Deibert 1997). Innis emphasized that a balance between space-based and time-based media is necessary for the governance of political communities across a far-reaching territory. For instance, his earlier works on the integration of Canadian areas into the French and the British empires demonstrated how the affordances of different technologies had constrained or counteracted certain collective activities and ways of organizing while enabling and supporting others (Innis

[44] One related aspect that warrants attention is the Eurocentric view that both entertain. Marx and Schumpeter took the industrializing path of Europe as a global benchmark (cf. Adas 1990, p. 241). Schumpeter, in particular, developed an account of the industrial revolution that implicitly foregrounds European superiority and creative agency. He denied economic explanations of Imperialism (Schumpeter 1919/1951) while neglecting the exploitation and violence necessary in the colonies to feed the machinery (see Duffield 2006, p. 21).

1938). Innis put emphasis on the diverging *political and administrative* consequences of the material specifics stemming from technologies or emerging industries. Through this analytical lens, we can see technologies, that is, their affordances are often at the core of power struggles between governments, administrative bureaucracies, companies, industries and even religious organizations (Innis 2007). Technologies, in short, have agential power as mediators:

> "For Innis, power was not an immediate relation among individuals or even groups. Social groups and societies typically seek supremacy over others. That struggle is socially and technologically mediated by communications media, but the primary function of communication, transportation, production and so on is to transmit information to move and make goods. These technologies and their functions are deployed by competing groups in their struggle for social supremacy. Technologies thus mediate power, but the causes of social action are not reduced to those technologies." (Di Norcia 1990, p. 347)

From this follows a difficult question: How to conceptually capture the dynamic and co-productive properties of technological innovations, which these classical writers have stressed in different ways? In other words, where is the place of the "material" in this? One interesting possibility touched upon the fascinating issue of agency may wait beneath the conceptual level of structure-agency problems. This would involve reconsidering the usual logocentric attribution of agency. In particular, close attention should be paid towards material agency without resorting to determinism (Dobres 2000, Hardie and MacKenzie 2007, p. 77).

What does it mean that the "material" really matters and has agential force? Does, for instance, the presumption suffice that technology possesses agency in the sense that is structuring the conditions or the opportunities for social activities (e.g. Logde 2007, p. 155)? Turning to the controversies reviewed in Chapter 2, this formulation is obviously problematic. For the opportunities that are assumingly offered by technologies to shape social behavior are neither intelligible nor transparent. They must be learned, practiced, and strategized. Moreover, the variety of options to use or prevent technologies from being used is highly contested in the first place. This point, however, does not mean that technologies might only become influential by being subject to symbolic representation. Such a social constructivist view is equally problematic because it would assume cognitive factors rather than material qualities to be structuring the possible social responses or appropriations (see Woolgar 1991, Dobres 2010).

Hughes and Cipolla suggested a more genuinely autonomous material trajectory. On the on hand, Cipolla (2011, p. 134) while summarizing Europe's early modern history suggested that technologies not only spur economic revolutions, but also exert a *cumulative effect*. Machines, he contended, would create the conditions for and eventually demand the invention and employment of additional machines. Hughes, on the other hand, concluded that technological systems, depending on their relative size, would develop a certain "technological momentum". The larger they grow—that is, the more people, expertise, infrastructures, institutions, political interest and investments they assemble—the bigger their impact will grow in shaping their own environments and other actors (Hughes 1994, p. 112).

3.4 Summary

The above considerations shed a new light on the conceptual roadblocks of dualism (instrumentalism vs. social reductionism) on the one side, and technological determinism on the other side. It would add to the empirical puzzles provided in Chapter 2 by reintroducing key issues in a more abstract way. Conceptually exploring technological innovations may require not only sophisticated methodological underpinnings (see Chapter 5), but also analytical sensibility to account for empirical complexities. To clarify the proper unit of analysis, the characteristics of innovation processes, and the potential distribution of agency should set the stage for theorizing the politics of innovation. In that sense, this interlude has equipped us with preliminary definitions: "technology" may signify the inexorable intermingling between material objects, social practices, and discursive utterances that is present in real-world ensembles; "innovation" may refer to transformative processes of (re)assembling that can not only reshuffle stable socio-technological ensembles, but also affect temporality and spatial dimensions. To accommodate to the agential aspects of this phenomenon, Chapter 6 and 7 would sort out types of agency that follow to the principle of symmetry.

4. Charting the Cartesian complex of IR

In recent years, the interest of IR scholars in technologies has been growing exponentially.[45] This chapter aims to review and discuss diverging theoretical approaches. It also proposes to trace the link between the discipline's dominant schools and the relative scarcity of conceptualizations of technological change. My assumption is that IR still retains a stunning "lightness" and, only through recent efforts, might be able to overcome it. Currently, therefore, artifacts, technological systems, and assemblages represent an extremely productive, yet challenging, issue area to develop new materialistic approaches and enrich existing IR theories (e.g. Acuto and Curtis 2014). But for a long time, technological innovations as such did not attract significant academic interest in IR and IPE—certainly not to the extent of their prominence outside academia (see introduction). This neglect contrasts with the historical research that we have encountered in the second chapter. Despite early attention and research by prominent scholars, concerns with the effects of technological changes were marginalized, particularly with the rise of systemic theories and, later, constructivism and post-structuralism. In this light, the first part of this chapter details the surprising degree of disregard for technologies within IR scholarship (4.1). This intriguing puzzle calls for an explanation. For how could IR have arrived at a point where technological innovations were off the picture rather than at the core of international relations? Why is this issue, which has become of utmost importance for economists and politicians, almost absent in IR and IPE?

To offer at least a partial answer to these questions, I assume that a "Cartesian complex" affects the development of the discipline.[46] By drawing on the philosophers Maurizio Ferraris (2013) and Bruno Latour (1999), the reference to Cartesian thought allows us to excavate the conceptual commitments underpinning IR's "lightness". René Descartes, who is often seen as inaugurating modern thinking, generated a highly influential intellectual tradition. Based on his skeptical attitude towards human

[45] Indeed, my observation when I started this work almost eight years ago, that there is a scarcity of research on that topic, now appears no longer correct.

[46] Several IR scholars (Wendt 2004, Poliout 2010) have proposed to develop post-Cartesian approaches without fully clarifying what this exactly means.

experience and sensual perceptions, Descartes' philosophy epitomizes logocentrism. Famaouly, Descartes' enshrined distinction between "res extensa" and "res cogitans".[47] This philosophical approach narrows down the things that exist in the world to what the human mind can (scientifically or logically) *know* (Ferraris 2013, p. 59). Descartes imposed, against the odds of the fluid and unfixed of the premodern worldview, his clear intellectual order that is based upon *differences* (cf. Foucault 2005). Part of this approach is the "transcendental fallacy" which strictly separates mind and matter. It also tends to privilege intellectual knowledge to such a degree that "reality, including physical objects, depends on our conceptual schemes." (Ferraris 2013, p. 60). Philosophers from Kant to Derrida, by following in Descartes' lead, have reduced the quest for reliable knowledge to studying conceptual schemes—resulting in an "anti-realist" focus on reason, rationality, and subjectivity, which theses thinkers confuse with epistemology and ontology (Ferraris 2013, Braver 2007).

Cartesian complex of International Relations theories		
Compartmentalization of knowledge and disciplinary politics	**Logocentric bias of ontological frameworks of dominant theories**	**Conceptual dualism in the form of technological determinism and externalism**

TABLE 4.1 THE THREE COMPONENTS OF IR'S CARTESIAN COMPLEX ©AUTHOR

Consequently, a form of ontological reductionism also became the hallmark of European reflections about legitimate politics and science henceforth (Latour 2005). Notwithstanding the numerous thinkers including Marx, Mackinder, Heidegger, Benjamin, Bergson, Whitehead, and Carl Schmitt who came to fiercely contest Cartesianism (albeit for different reasons), most contemporary IR schools are still used to the metatheoretical practice that eschews the "res extensa". The presence of pervasive technological systems, artificial objects, and the experience of technical mediation in

[47] I use the German translation of Descartes' original Latin text (Descartes 1637/1986). For an introduction to Descartes' philosophy see Prado (1992).

every conceivable human interaction remain unaccounted for. It is in this sense that one encounters the specter of Descartes when reading, digesting, and re-reading many sublimely crafted IR texts.

The following section, than, unpacks the practical, ontological and conceptual elements of IR's Cartesian complex: Firstly, research about technological innovations has suffered from systematic academic compartmentalization (4.2). Secondly, the ontological framework that is shared by leading theoretical approaches to IR has a strong logocentric bias (4.3). Thirdly, the approaches that explicitly deal with technological innovations belong either to the determinist or the externalist champ. Both rely on a dualism that, according to the drama of technological innovations outlined in Chapter 2, leads to conceptualizations of technology which are overly simplistic (4.4). In contrast, the third group of approaches that is underpinned by the idea of "coproduction" offers viable theoretical bridges over, or circumnavigations of, the Cartesian complex. I examine the coherence of their theoretical frameworks, that is, how they construe the mutual constitution and complex embeddedness of technology and social order. While having some limitations at the conceptual and methodical level, coproduction works in IR are focused on certain technologies, technical systems, or processes (4.5).

Coproduction approaches, thus far, have led to few attempts to create a more general theory of technology and international relations. Most of these works are isolated studies and did not inform or feedback into mainstream IR debates. Their research concerns were, with few exceptions, articulated in the conceptual straitjackets of other topics, domains, or debates within IR. Hence, exploring technology under conditions of the Cartesian complex necessarily displays shortcomings. The following, then, sketches out a philosophical mapping of the lightness of IR, while Chapter 5 (5.1) further unpacks the historical context of its emergence.

4.1 The strange fate of technology as a research concern

For a long time, technological innovations as such did not attract significant academic interest in IR and IPE—certainly not to the extent of their prominence outside academia (see introduction). This neglect contrasts with the historical research that we have encountered in the second chapter. As we have seen, various Victorian thinkers in the eighteenth and nineteenth century were preoccupied with the effects of navigation instruments, timepieces, cartography, and undersea cables for the governance and pursuit of power over time and space within the empire (Bell 2005). At the turn of the nineteenth century and during the interwar period, numerous geopolitical thinkers explored the impact of railways, steamships, high explosives, and airplanes on the land-sea balance, power, and colonial rule (C. Gray 2004, Ashworth 2013). In *Conditions of Peace*, E.H. Carr argued that modern technological developments have pushed the nation state into crisis and even rendered the state-system obsolete (Carr 1942).

In 1949, William F. Ogburn, editor of the first extensive IR treatment of our subject matter, expected that technological change would turn into a major new field of research (Ogburn 1949).[48] Prominent scholars including Quincy Wright, William T. R. Fox, John Herz, and Bernard Brodie among others began to explore modern technologies and infrastructures, drivers and results of industrialization, whose "effect upon world politics is impossible to ignore, even though it varies in each case" (Buchan 1972, p. 162).[49] Meanwhile, scholars such as David Mitrany, Ernst B. Haas, and Joseph Nye explored the emerging cross-border communications and transnational global linkages through regime theory or (neo)functional integration theory.

In the 1950s and 1960s, moreover, numerous observers and practitioners desperately struggled with the question of how to control technological changes that appeared to inevitably spur conflicts and even full-fledged nuclear war (Deudney 2000b, pp. 19-22). While "deterrence" was not yet established in theory and practice, the essential question moving theorists and practitioners was how to cope with the effects of uncontrollable technological progress—particularly strategic weapon technologies—on international relations. Hans J. Morgenthau warned that the "modern scientific age" had essentially altered domestic politics, "dramatically" decreasing "popular participation in, and control over, the affairs of government" (1964, p. 1386), while John Herz theorized

[48] Ogburn, a sociologist, was among the pioneering researchers exploring technological transformation and material culture. For a comprehensive review see Godin (2010).

[49] See also Mackinder (1919, 1942), Carr (1942), Turner (1943), Herz (1959), Sprout and Sprout (1960), Sprout (1963).

the deterritorializing effects of nuclear weapons on states (Herz 1957). Strategies to handle nuclear weapons became the central research concern of a large epistemic community during the 1950s and 1960s (see Ayson 2000). As Chapter 5 details, select realists have developed an explicit critique against the prevalent naive and apolitical belief in technological progress (Scheuerman 2009). But, since the 1970s, technology has faded away from the radar screens of theorists as these works have left few traces among current students of IR.

While the reorientation of IR after 1989 may have shaken some fundamentals of the discipline, technological innovations, and in particular its poster child, the information revolution, have not received significantly more attention as a research matter. Ronald J. Deibert, writing in 1997, emphasized the "dearth of scholarship in the International Relations/communication technologies nexus". He notes that "to the limited extent International Relation theorists have dealt with communications explicitly, the focus has primary been on the *content* to the exclusion of technology" (1997, p. 5, 18). A decade later, Johan Eriksson and Gimapero Giacomello 2006 still draw the same conclusion:

> "The end of the cold war resulted in a major crisis not only for neorealism (reputedly, the most successful of IR theories), which had failed to predict and explain that turn of events, but also for IR in general. But although much has been written about the cold war's end and the associated need for redefining IR theory, particularly for increasing its external validity, surprisingly little has been written about the information revolution and what challenges this implies for IR theory." (Eriksson and Giacomello 2006, p. 223)

The dearth of scholarship about other technologies beyond telecommunications was even more acute. Despite a growing number of studies on the politics of cyberspace,[50] the current generation of IR students still becomes socialized in a purified conceptual world that omits technology. From reading textbooks and introductions to International Relations one cannot but come to the conclusion that technology and technological innovations are irrelevant. Consider two recent major edited volumes introducing the reader to *International Relations Theories: Discipline and Diversity* (Dunne, Kurki, Smith 2010) and *The Globalization of World Politics: An Introduction to International*

[50] Cf. Deibert and Rohozinski (2010), Singh (2013), Mueller (2012), Carr (2012).

Relations (Baylis, Smith, Owens 2011). The structure of both works is symptomatic: it completely leaves out the topic of technological innovations. The subject matter is not just missing from the theory chapters, but is strikingly almost completely absent from the topical parts.[51] The global (technological) transformations originating in the nineteenth century are, as Barry Buzan and George Lawson (2013) stress, are virtually omitted in textbooks.

In addition, the non-existence of both an IR journal and a special subfield broadly dedicated to this subject matter indicates the magnitude of neglect—not to mention the lack of respective IR chairs or branches within the university systems.[52] STAIR, the section on science technology arts and international relations of the International Studies Association (ISA) has just been established in 2015. As a result, IR and IPE theory is rather out-of-sync with its non-academic audience:

> "The pervasive mutual influences of science, technology and international relations, and their importance to global governance, make the isolation of science and technology from the 'mainstream' of international relations a curious anomaly in the 21st century." (Weiss 2005, p. 308)

The claim that technological innovations are a broadly marginalized topic and research focus (Herrera 2003, Weiss 2005, Fritsch 2011) is also substantiated by systematic data on publications. It is clearly reflected, for instance, in the content of journal articles published in major IR journals (see table 4.2). A systematic search in online archives reveals that, on average, less than 1.7 percent of the all articles published between 1990 and 2009 dealt with "science and technology". *Alternatives* and *Millennium* show the highest score with roughly four percent relevant publications.

Journal	**Period covered**	**Number of articles concerning "Science and/or Technology"**	**Percentage share of ST-articles**
Third World Quarterly	1990-2007	13	1.08

[51] Notable exceptions are Lawton, Rosenau, and Verdun (2000) and Balaam and Veseth (2008). These books, which draw their inspiration from Susan Strange's work, are to my knowledge the only general introductions to IPE/IR that grant knowledge, innovation, and technological change a full-fletched chapter.

[52] A skeptical reader might say: IR confronts the proliferation and control of nuclear weapons that is a high technology. Yet, in concepts and empirical account, as will become obvious later, nuclear weapons are treated as merely social problem: as a challenge to collective interactions (deterrence).

Foreign Policy	1990-2009	13	0.60
International Organization	1990-2009	6	1.06
International Studies Quarterly	1990-2007	11	2.17
International Affairs	1990-2007	23	0.38
International Security	1990-2007/08	15	2.88
International Political Science Review	1990-2009	10	2.24
Journal of Conflict Resolution	1990-2009	5	0.72
World Politics	1990-2009	2	0.76
Foreign Affairs	1990-2009	28	0.38
Alternatives: Global, Local, Political	1990-2009	18	4.05
Review of International Studies	1990-2007	10	1.83
International Studies Review	1990-2007	2	0.93
Millennium: Journal of International Studies	1990-2013	31	3.95

TABLE 4.2 NUMBER OF JOURNAL ARTICLES CONCERNING SCIENCE AND TECHNOLOGY[53] ©AUTHOR

Furthermore, when technological innovations were a subject matter, theoretical interests played a minor role. On average, only about six percent of all texts dealing with technologies, which were published between 1990 and 2007, focuses on conceptualization and theoretical considerations. *Millennium* and *The Journal of Conflicts Resolution* are exceptions, ranking highest with 22 percent and 20 percent theory-focused articles respectively. Overall, merely eleven articles out of 21.866 items, which make up our sample, display a substantial interest in theorizing technology or technological innovations (see table 4.3).

[53] Data on all journals – except Millenium: Journal of International Studies – was provided by the Jstor database. Data on Millenium journal was provided by SAGE journals homepage. All data was collected in August/September 2013. Mapping and classification of articles was based on a qualitative approach: In a first step, the search for science and technology related articles was based on the keywords "science" and "technology". In a second step, irrelevant articles were filtered out manually. Eventually, the classification of relevant articles was carried out keyword-related according to the content of abstract and title. All articles were classified within twelve categories with different keywords: "Environment and Energy" (e.g. environment, energy, pollution, energy supply), "Climate Change" (e.g. climate change, ozone, sea-level rise). "Information and Internet" (e.g. cyberspace, information- and communication technologies), "Innovation" (e.g. innovation, invention, innovation systems); "Outer Space" (e.g. satellites, space technologies, space law), "Biology" (e.g. stem cell research). "Agriculture and Food" (e.g. genetically modified food and organism, seeds), "Technology" (e.g technology, high technologies, products), "Medicine" (e.g. HIV and Aids research, epidemics, drugs), "Science and Development" (e.g. research, science, development), "IPR" (patents, generic drugs) "Nuclear Warfare" (e.g nuclear weapons, nuclear missiles), "Other Warfare" (e.g. military technologies, biological and chemical weapons), "Theory" (e.g. ANT). The total number of substantial articles disregards book reviews, forewords and editorials.

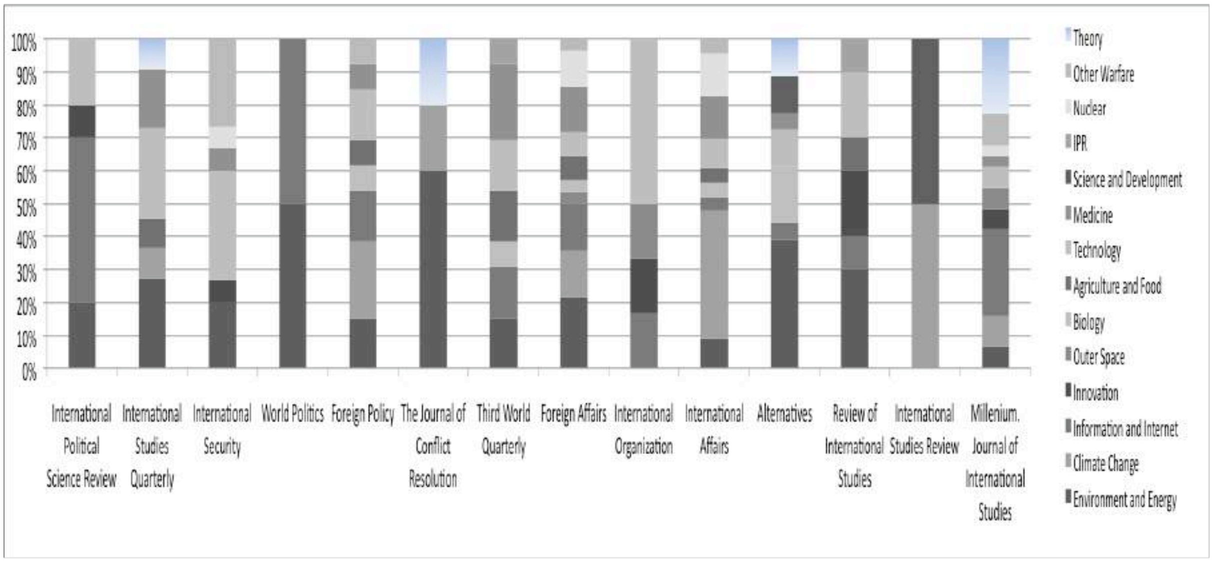

TABLE 4.3 TOPICS OF JOURNAL ARTICLES CONCERNING SCIENCE AND TECHNOLOGY (SAME SOURCE AS TABLE 4.2) ©AUTHOR

Against this background, it becomes obvious that the works examined below are hardly dotted light towers in a dark landscape. Their perspectives and insights resemble—judged on the basis of their contributions to broader IR theory building efforts—silos. But why should the disappearance of technological innovations concern us? Some scholars might reject the relevance of these observations by suggesting that, while deterrence theory solved the most pressing issue concerning nuclear technology, the number of existing works sufficiently captures the scope and diversity of the matter at hand.[54] Indeed, IR scholars have produced widely diverging claims about the role of specific technologies for the conduct of international affairs and foreign policy—ranging from their irrelevance to their preponderance. Eugene Skolnikoff (1994), for example, finds that science and information technologies had a limited impact on diplomatic practice and foreign policy. In contrast, others see "techno-globalism" challenging or even overriding state authority (Ostry and Nelson 1995). Robert Gilpin (1981) stresses the critical importance of technological innovations for the occurrence of war. Based on a materialist approach, Daniel Deudney (2006) claims that the co-evolution of military technologies and defense infrastructures determines national security practices. From a poststructuralist view,

[54] In addition, one might simply argue that IR's silence is not remarkable at all by stressing that a certain division of labor is unavoidable. Why should one interfere with a field that firmly belongs to economics or, at least, to International Political Economy? Yet, as will be discussed in a minute, the very same omission is unfortunately also evident in IPE.

James Der Derian (2003) sees information technologies enabling a profoundly novel coagulation of surveillance, warfare, entertainment, and US power projection. The appreciation of these works should not prevent us, however, from realizing that they are marginal and insular in the context to the discipline. There is a lack of integrative approaches and comparative studies on technological innovations (see 4.5).

IR's indifference towards technological innovations appears even more pronounced if we compare it to the contemporary attitude of governments, corporations, international organizations, and militaries (Weiss 2005). The great zeal with which practitioners use slogans and implement policies concerning "technological leadership", "human capital", "revolution in military affairs", or "indigenous innovation" and so on is definitively absent in IR. The vanishing of technology as a research concern is also puzzling when we consider that other disciplines such as geography, sociology, anthropology, philosophy and history have at the same time established subfields, theories, journals and debates about technology. It is against this background, that the idea of the Cartesian complex seems to offer a plausible explanation for IR's collective neglect. But before shedding light on the ontological and conceptual levels, we first need to clear the ground by examining how the disciplinary division of labor turned into another obstacle hampering the study of technological innovations.

4.2 The compartmentalization of knowledge

Scholars have repeatedly lamented that the discipline of IR is like a container. This reality certainly has damaged our understanding of technology. Three conventions govern the compartmentalization of professional knowledge of IR scholarship that confuse our understanding of technological innovations. The first common problem is the deliberate endowment of economists with the supreme authority to analyze and speak for technological innovations. The second obstacle lies in the static concepts, which were imported from economics. The third issue is the widespread ignorance of insights from other disciplines. In the course of this section it eventually will become obvious that such "disciplinary politics" prevent a clear elaboration of how the paradoxes of technological innovation call into question state-centric and instrumentalist problem-framings.

While the disciplinary division of labor sometimes makes sense, it is unfortunately misleading in the case of technological innovations. It tends to put the premium on economic and, in particular, econometric research that provides wide-ranging statistical data, international rankings, and global assessments. The impressively rich graphical and pictorial texture of recent OECD or UNESCO reports purports overwhelming matter-of-fact statements about innovation and technology. Yet, hidden behind their monumental façade are unconvincing methodical moves. They foreground monolithic states and national economies in the analysis of innovation processes and innovativeness while it is unclear which actors are the most important, how they are related to one another, and across which levels innovational processes—local, regional, national, continental, global to name a few—take place (Etzkowitz and Leydesdorff 2000, Montresor 2001). It is for example erroneous to treat the "state" as a unitary actor because various "strategic groups" inside state agencies and across institutions may push innovations and knowledge growth (Evers, Menkhoff, and Wah 2010).

Dynamic accounts of innovation reject the notion of "national innovation systems". They emphasize the co-evolution of mutually interacting fields—labeled as "tripple helix"—comprising industries, universities and governments (Etzkowitz and Leydesdorff 2000). Typically, these studies assume the co-evolution of technological innovations, the applications and diffusion of technologies on the one hand, and the regulative environment on the other (Leydesdorff and van den Besselaar 1994). As companies, universities, research institutes, and entrepreneurs are the primary actors "doing" innovations, their activities typically evolve within complex transnational and trans-sectoral networks. These networks are social and commercial at the same time, comprising both collaboration and competition (de la Mothe and Dufour 1995, Archibugi and Lundvall 2003, Srholec and Verspagen 2008). Innovational processes and scientific collaboration often transcend national borders while they are unevenly distributed and spatially highly concentrated in metropolitan areas (Evers 2008, Hornidge 2008, de la Mothe 2004, Castells and Hall 1994).

As a consequence, politicians who attempt to govern or steer innovations in developed and developing nations alike experience them as tricky and elusive (Breznitz 2007). The great difficulties of governments are illustrated by the irresistible blurring of the lines between commercial and military applications. Because almost every high technology embodies dual use functions, even powerful states have failed to prevent "their" cutting-edge weaponry and expertise from diffusing. The research and development of high-tech weapons, surveillance and military equipment, system software and so forth become ever more intertwined with a diversity of private firms and civilian research institutions (Molas-Gallart 1997, Molas-Gallart and Sinclair 1999, te Kulve and Smit 2003). The ability of the "state" to control or to govern the knowledge society from its commanding highs is limited. Nevertheless, numerous econometrical studies by drawing on aggregated national data sets construe nation states as central units. Comparative research, similarly, stresses the state by assuming that national institutions and innovation systems matter most for explaining differences in technological innovations and economic performance (Lundvall, Joseph, and Chaminade 2009).

Adam Segal points out the "mismatch between traditional S&T analysis, based in the national innovation school, and an increasingly international process." (Segal 2008, p. 423) The resulting empirical and theoretical contradictions are mirrored in the impenetrable policy tradeoffs that governments often have to tackle (Godin 2002, Robertson 2008). The methodological focus on "states" or "national economies" conceals more than it reveals. And the aggregated data sets that we currently have at our disposal are not useful if we take the fluid technological world seriously. Moreover, theory-driven frameworks are lacking that combine statistical calculations on the one hand and qualitative observations in the other. In sum, the dominance of mainstream economics over this field reinforces the inadequate picture that innovational activities constitute *inter-national* issues.

Perhaps most problematic is that the methodologies used by international organizations such as the OCED and the UNESCO render technological innovations and the resulting shifts a purely economic issue. One surely cannot fault economists for their prime concern with economic issues. Yet, positivist-quantitative research and indicator-based econometrics often purport a thoroughly non-political depiction of innovations.

Especially global power dimensions are left out from the picture.[55] To explain different growth rates and national wealth, innovation economics almost exclusively focus on national institutions and policies (Acemoglu and Robinson 2012, Acemoglu, Aghion, and Zilibotti 2006). To the extent to which the world is construed as if no links exist among innovational processes, technological change and international power politics, the neglect of this political dimension is no mistake. Nor is it simply due to a narrow disciplinary mind-set. The OECD places innovations in the context of growth-friendly policies, market competition, and collaborative responses to global challenges in order to figure them as problem-solutions rather than matters of power-political concerns. Technological innovations are consequently seen as

> "essential if countries and firms are to recover from the economic downturn and thrive in today's highly competitive and connected global economy. It is a powerful engine for development and for addressing social and global challenges. And it holds the key, both in advanced and emerging economies, to employment generation and enhanced productivity growth through knowledge creation and its subsequent application and diffusion." (OECD 2010, p. 2)

One can doubt the merits of de-politicizing the diffusion of technologies. However, if the OECD outlook holds true and our societies and economies undergo fundamental transitions that render high technology progressively pervasive and prominent, it is equally reasonable to assume that this transition will—as the historic examples discussed in Chapter 2 amply illuminate—inevitably entail power dimensions.

Of course, this is not to imply that quantitative indicators for technological capacities or innovativeness should be abandoned (see Leydesdorff and Zhou 2005). However, the quantitative explorations of innovative capacities, economic competitiveness, and technological leadership are unsatisfying from an analytical perspective: The power aspects of technological transformations fall victim to over-quantification (in economics) and suffer, at the same time, from constant under-theorization and under-specification (in economics and IR). At this point, the tendency in

[55] International aspects are either framed as long-term pattern such as "Contradiev cycles" or as policy misfits and coordination problems (e.g. Dosi et al.1988).

But see Castellacci and Archibugi (2008), and Archibugi and Coco (2005) for excellent examples that render visible the power aspects empirically and conceptually.

IR to delegate the subject matter, and the economists' preference for framing it in apolitical terms of problem solving, are mutually reinforcing.

The second disciplinary obstacle that inhibits conceptualizing technological innovations is the custom of IR scholars to selectively borrow only from economics, and pay little attention to other neighboring disciplines. As a result, some of the core ideas underpinning IR thinking essentially prevent theorizing technological innovations. This observation seems, at the first glance, confusing for almost every systematic theory of international relations or international political economy has borrowed from major economic thinkers. Almost every feature of economic theories has either come—in one way or the other—to underlie theoretical approaches to IR, or has been discussed as both a policy concern and, from a critical perspective, a site of resistance: these notions include trade, production, monetary systems and currencies, global markets, transaction costs, and interest groups.[56] At the level of theoretical assumptions, a micro-economic rational-actor model is the most commonplace imported tenet of economics (Guzzini 1993, p. 444).

But there is also an interesting exception. Why has the evolutionary dynamic of innovations consistently been ignored both issue-wise and on the level of theorizing?[57] The reason for this is simple. IR and IPE have exclusively borrowed from strands of economic theory that tend to downplay innovations systematically.[58] Specifically, Joseph A. Schumpeter's concept of "creative destruction" has not been picked up in IR. Schumpeter's ideas are the main source of inspiration for innovation economics and the New Economic paradigm (cf. Hospers 2005, Witt 2003), which see innovations as the

[56] Other theoretical puzzles include global governance and regulation, the dichotomy between market forces and state authority, the integration of economies in a regional or world market, trade barriers, state capacity, financial systems and currencies, transnational corporations, and so fourth (Garret 1998, Rodrik 1997, Moravszik 1993, Gilpin 2001, Underhill 2003, Hobson 1997, Kugler and Domke 1986, Spero and Hart 2010). Marxist approaches theorize international relations instead based on the concepts of class struggle, exploitation and resistance, core-periphery relations, and forms of hegemony (Cox 1981, 1987, Wallerstein 2004, Gill 2003).

[57] Although scholars have advanced "evolutionary theories" in IR they are not related to technological innovation at all.

[58] The concepts and puzzles derived from Smith, Ricardo, Marx and neoclassical economists have directed the theoretical focus to certain aspects of the capitalistic economy while neglecting others. Indeed, when asked to treat innovations in a substantial manner, especially classical equilibrium economics fails to deliver (Romer 1994).

foremost driving engines for growth and economic progress. Hence, this perspective is by and large missing in IR and IPE.[59] One needs only to consult Benjamin Cohen's (2008) brilliant intellectual history of *International Political Economy* in which great thinkers of innovation including Joseph Schumpeter are anathema. The entire book does not entail a single section that substantially deals with technological innovations either as an empirical concern or as a theoretical subject matter.

While this sort of selection bias is not unusual for intellectual appropriations from extra-disciplinary sources, its thoroughness is striking. Not only neorealist, but also liberal and Marxist IR approaches have literately turned a blind eye to technology-based development and innovation processes.[60] There is no good explanation for the fact that evolutionary and non-static innovation economics were simply not embraced for conceptual inspiration. The ramifications are obvious. The reservoir of economic vocabulary that explores the evolutionary dynamics of technological innovations – skipping assumptions of equilibrium models or static circulation-economies (Aghion and Howitt 1992, Metcalfe 1998, Freeman 1988, Dosi and Nelson 1993) – has not been mined. In sum, IR scholars cling to their static assumptions, despite the rise of evolutionary economics and the renaissance of Schumpeter's ideas which ushered in non-equilibrium models (Romer 1990, 1994, Freeman 2007). IR theories—under the intellectual guise of preeminent "classical" economists—have simply overlooked technological innovations.

It does not follow, though, that IR should shy away from economics. Clearly, economic insights inadvertently bear on IR. Particularly, I will later draw myself on innovation economics to develop my framework. Against Higgot and Watson (2007, p. 16), who state that "it becomes progressively less tenable to present economics as 'the approach' to explaining social reality rather than as one approach amongst many", it is worth noticing that essentially different economic theories exist. Although I agree with

[59] In this sense, John Stopford and Susan Strange (1991) and John de la Moth and Gilles Paquet (1996) are noteworthy as they attempt to capture interactions between emerging technologies and power. Stopford and Strange, for instance, stress "investments in competitive innovation have proved decisive in determining who gains leadership on the world stage and who loses" (Stopford and Strange 1991, p.66).

[60] To a certain degree, world system approaches have paid more attention (e.g. Arrighi 1994). Yet, most scholars in these groups are not pledging allegiance to IR, if they are not in an outright opposition to the discipline (Buzan and Little 2001).

Higgot and Watson that several other disciplines provide valuable inspirations, IR would especially benefit from the New Economics' paradigm shift towards dynamic, non-linear models.

The third and last aspect of disciplinary politics is the neglect of non-economic research. As IR theorists—including scholars who approach technologies—rely on misleading thoughts of economists, they have largely refrained from *adopting and incorporating* the rich conceptual frameworks and materials about technological innovations advanced by neighboring disciplines.[61] Indeed, sociology, history, geography, anthropology, archeology, and science and technology studies (STS) did long acknowledge the reality of the technological world. They have accumulated a large body of knowledge that highlights the massively transformative and productive character of technologies.[62] Although some studies directly point to international affairs,[63] IR scholars have eschewed these insights. They were not used in order to recalibrate and refine IR theories.[64]

Hence, what Chris Brown has noted concerning the entire discipline is especially relevant for the study of technological innovations: "it is embarrassing how often IR theorists find themselves grappling with problems that have been current elsewhere in the social sciences for decades." (2007, p. 350) As a result, techno-politics are subject to a powerful collective state of denial in IR—otherwise, IR scholars certainly would have started to fight over this turf as well. Instead, a learning attitude is needed. IR would certainly benefit from importing empirical knowledge and methodological know-how. However, given the problematic inappropriateness of existing frameworks, does "incorporation" actually make sense? It could be argued that pressing the empirical observations and theoretical concepts, which are to be imported, into insufficient frameworks would lead to foretold stillbirth.

[61] Tellingly, these disciplines were not occupied with the business of establishing *one distinct* subject matter that embodies the sacred cow of the scientific community. And, perhaps, the former were not as much yearning for academic identity as was postwar IR.

[62] See footnote 4.

[63] See Headrick (1979), Adas (1990), Jasanoff (2006), Krige (2006a), Krige and Barth (2006), Winseck and Pike (2007).

[64] The important outliers such as Der Derian (1990), Deibert (1997), Litfin (1999), Singh (2002), Deudney (2000a) and Herrera (2003, 2006) will be discussed below.

Untying the Gordian knot demands a radical cure. We ought to grant IR theories a break because integrating insights from other disciplines requires first of all open-mindedness. To this end, we should assume a genuine empirical/conceptual interdisciplinary field that contains the "global politics of science and technology". As one needs to build this field almost entirely from scratch, this enterprise benefits from the supply of fresh empirical materials and conceptual tools (cf. Mayer et al. 2014a). To be sure, combining notions and concepts in an interdisciplinary way does not imply that we must completely sacrifice theoretical parsimony. Yet, parsimony should not be mistaken as an excuse for over-simplistic models including logocentric ontologies and static assumptions. To establish a new subfield in IR constitutes an enormous long-term project – to which this book only can make a small contribution. Nonetheless, removing the roadblocks of compartmentalization renders our thinking about technological innovations more fruitful.

4.3 The logocentrism of IR's ontological framework

If one agrees that we have to acknowledge the significance of transformative technological innovations, how can we explain that mainstream IR theories are so far off the mark? Why are the "mainstream" theories such as neo-realism, neo-institutionalism, and constructivism silent about these empirical matters of fact? Probing into the compartmentalization of knowledge has just scratched at the surface of IR's Cartesian complex. Examining the ontological assumptions that are widely shared by the academic community produces a clearly shaped account of the puzzle of lightness. For this purpose, I revisit Kenneth Waltz's influential *Man, the State and War*. A reconstruction of his brilliantly parsimonious line of arguments reveals an ontology that completely eschews the material world. As Waltz is often credited for being the most influential IR theorist, it turns out that his version logocentrism also underpins other systemic IR theories.

The first important clue concerning ontology derives from the way in which Waltz defines his central problem—the occurrence of war.[65] Waltz's introductory remarks set

[65] To be precise, Waltz' book deals with inter-state war. It does not cover civil wars, mercenary conflicts, religious wars, colonial conquests, resource wars, ethnic cleansing, tribal warfare, and so on. His narrow

the tone: “War begins in the minds and emotions of men, as all acts do” (Waltz 1959, p. 9). When Waltz subsequently frames collective action under conditions of anarchy, he does so by drawing on contract theorists; and mainly on Rousseau (Waltz 1959, p. 161-186).[66] Referring to Rousseau, Waltz notes that “if harmony is to exist in anarchy, not only must I be perfectly rational but I must be able to assume that everyone else it too. Otherwise there is no basis for rational calculation.” (Waltz 1959, p. 169) Waltz refers to a famous story that embodies the state of nature to layout the concept of anarchy. Writes Waltz:

> “Rousseau illustrates the line of reasoning with the simplest example. The example is worth reproducing, for it is the point of departure for the establishment of government and contains the basis for his explanation of conflict in international relations as well. Assume that five men who have acquired a rudimentary ability to speak and to understand each other happen to come together at a time when all of them suffer from hunger. The hunger of each will be satisfied by the fifth part of the stag, so they ‘agree’ to cooperate in a project to trap one. But also the hunger of any one of them will be satisfied by a hare, so, as a hare comes within reach, one of them grabs it. The defector obtains the means of satisfying his hunger but in doing so permits the stag to escape. His immediate interest prevails over consideration for his fellows. The story is simple; the implications are tremendous.” (Waltz 1959, pp. 167-8)

In other words, anarchy is “weightless”: the perennial collective action problem of IR plays out primarily in and between human minds. Consequently, Waltz (1959, pp. 235-237) sees weapon technologies as merely ephemeral. There is, conceptually, no difference between a world with spears and a world with nuclear warheads. He argues that even nuclear weapons are not able to override the constant threat of war between sovereign states as a result of international anarchy. Anarchy, according to Waltz, always remains a collective action problem solely posited in terms of mind-mind-interactions. The only independent function granted to technology is their influence on rational calculations: “nuclear weaponry”, writes Waltz later, ”makes miscalculation difficult because it is hard not to be aware of how much damage a small number of warheads can

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concept of war thus foregrounds states while the material category of war is not nearly comprehensively covered in his discussions.

[66] On contract theories as conceptual resources for IR theories see Jahn (2006) and Beitz (1979).

do." (Waltz 2008, p. 418)[67]

The "weightless" view of *Man, the State and War* is anything but an outlier. Ontological logocentrism is widespread among foundational texts of IR. Consider for instance Hedley Bull, another founding fathers. Like Waltz, he reduces the world to social interactions, although his arguments fundamentally contradict Waltz' neorealism. Bull sees *The Anarchical Society* as a functioning, rule based order. "International order", he proposes "is order among states; but states are simply groupings of men" (Bull 1977, p. 20). Like Waltz, Bull does not enlist material artifacts in his initial description. Technology is thus not constitutive to the world assembled in his classical work. Of course, Bull cannot silence technology completely. When he examines the balance of power, suddenly, "industry and military organisation" and "military technology" slip in to the picture (Bull 1977, p. 102). He determines the defining moment of war as the threat to "common values, rules, and institutions" (Bull 1977, p. 187). As Bull discusses nuclear deterrence strategies, he mentions that "even without nuclear weapons war for an advanced state can involve such *physical destruction*, and such political, economic, and social dislocation as to make war almost unthinkable as an instrument of policy (…)" (Bull 1977, p. 194; italics added by author). Astonishingly, Bull spends no more than a single paragraph to hint at the planetary technological infrastructures that sustain modern life and might be subject to "dislocation". In the same vein, another proponent of the English school notes "change in institutions can have much greater impact on the daily lives of ordinary people than most technological innovations." (Holsti 2004, p. 19) Ultimately, the English school relegates technological changes to the conceptual sidelines.[68]

Robert Cox, who is known for bringing back a materialist (Marxist) approach into IR, surprisingly, advances a similarly logocentric emphasis. Cox (1981, 1987) draws on Marx and Gramsci to develop his conceptual framework of global change. He proposes a triangle in which the production forces (i.e. the "material conditions") interact with ideas or ideologies on the on hand, and institutional settings that order regulations and

[67] For a more detailed exploration of Waltz approach to technology see Chapter 5.

[68] But see Buzan and Lawson (2015) who acknowledge massive socio-technical change, yet ultimately do not adopt the English School's central concept of „institutions".

governance on the other hand (Cox 1987, May 2009, p. 40). Yet, the production forces do not reflect recurring waves of technologies, but are first of all defined in terms of social class. As Cox outlines ontological parameters in a more recent text, he immediately narrows down agency to intention-capable actors.

> "The first ontological question is: What is power? And the second is: Where does power lie in the present world order? 'Power' I take in a very general sense to mean whatever force can *intentionally* bring about change in the behaviour of any of the diversity of agents in world political economy. I do not assume *a priori* what those forces or those agents are. States are obviously to be included among the agents. Military strength and the capacity for economic coercion are obviously to be included among the relevant forces. But there are many other things in each category." (Cox 2004, p. 308, italics added by author)

The crucial point here is not to single out theoretical approaches for logical errors or lack of parsimony. Rather, these eminent scholars epitomize pars pro toto a theoretical commitment of IR that is underreflected. Despite their otherwise huge differences, Waltz's, Bull's, and Cox's approaches similarly construe international relations as a social matter, that is, human-to-human or mind-to-mind interactions. In as much as human interests and social interactions are mediated through norms, institutions, and regimes, the latter concepts are defined in purely intentional terms. Such an ontology exclusively grants agency to "social" agents, which ultimately means rational calculus, ideas and subjectivities.

Constructivist (and post-structuralist) scholars even amplify this logocentric bias. Although the family of constructivist approaches embodies huge conceptual differences, they are equally neglecting artifacts, technical systems and material objects. As such, they treat international relations exclusively in terms of "intersubjective relations", "norms", "discourses", "speech acts", "framings", "signals" or "ideas". Alexander Wendt, for example, famously argued that IR—except for some inescapable constrains of "rump matter"—eventually is "ideas all the way down" (Wendt 1999, p. 110). Though Wendt's *Social theory* rests on a critical realist meta-theoretical foundation, which explicitly acknowledges the existence of an "objective reality", inter-subjectively enacted identity remains the central focus of activity, and therefore, domain to capture, order, and explain international relations (Zehfuss 2001). As Wendt states, "by virtue of its dualist ontology in particular *Social Theory* is fundamentally Cartesian in its worldview" (Wendt 2004, p.189). The same applies to power concepts that refer to knowledge or discourse (see Barnett and Duvall 2005). The very term "soft power" (Nye 1990, 2008) is suggestive of a sublimation of the material world.

Furthermore, it could be argued that studies of epistemic communities involve a subtle materialist move. For assuming scientific knowledge can influence international negotiations and helps to set the political agenda implies, if indirectly, to bring "nature" back in. Yet, all these approaches enmesh the potential agency of the material in a profoundly logocentric perspective. The emergence of objects (and subjects) is always conditioned by scientific discourse and in form of "purely ideational representations" (Allan 2017, p. 157). The same ideational tendency is inherent to the Copenhagen's school of securitization theory that, consistent with radical constructivism (Buzan, Wæver, and de Wilde 1998), deliberately eclipses all technological or material elements of reality in its model (McDonald 2008).

Poststructuralist scholars in general see their subject matter primarily through and as textual discourse (Wight 2002) but their analytical tools can involve a subtler reading of materiality than most other IR theories would allow for (Fierke 2003, see also the discussion in Jasanoff 2004b). Campbell (2007) insists that material artifacts, like ideas, are elements of performative processes—substantiated for example by his analysis of images and videos about humanitarian emergencies. As an important source for "critical" security studies, poststructuralists have expanded the subject matter of security enormously (Walker 1991). Yet, no conceptual language was advanced to capture technologies and there effects although for Walker "the acceleration of modern life has caused the distinction between time inside the state and outside the state to collapse" and due to "speed and acceleration (…) space is compressed and borders are becoming less significant, and so too is state sovereignty" (Mckay 2016, p. 5). Materials, which can shape subjective experiences such time, do not become discursive agents in their own right (see Campbell 2007, Walker 1993). For example, critical security studies see the predicament of failed states such as Congo in the formation of developmental discourse by the international community rather than in the material conditions experienced at the ground (Schouten 2013). Poststructuralist approaches in fact have great difficulties to develop analytical lenses and conceptual vocabularies that capture and explore "material" beyond text and representation.[69]

To map "postmodern" moves of sublimation that are typical for IR theories should not, however, distract us from scholars who have enlarged the ontological parameters beyond the perspective of logocentrism. Most notably are James Rosenau, Robert Cox, Saskia Sassen, Barry Buzan, and Susan Strange who have dedicated their research to understand international politics more comprehensively from economic, historical, and social angles (Strange 1988, Rosenau 1990, 2003, Cox 1987, Sassen 2006). And yet, their efforts have produced mixed results with respect to technological innovations. Strange's examination of "secondary structures" of global energy supply and transport as "important in their own right" (Strange 1988, p. 139) has not been followed up in IR.

Another group of scholars who write in a feminist tradition displays similar expansionist energies. Cynthia Enloe (2000), Christine Sylvester (1994), Ann Tickner (1998), and Alison Howell (2011) among others are pushing the ontological envelope of IR by proposing to include bodies, persons (other than states men), and emotions as crucial elements of international politics (Youngs 2008, Blanchard 2003). It is obvious that these and other scholars have opened up many interesting avenues for "materialist" research.[70] Tapping into their conceptual vocabularies and empirical observations helps to theorize new technologies and the techno-scientific world writ large (Howell 2014, see 4.1).

Despite these attempts to broaden the ontological scope of IR, logocentrism still is in a dominant position – the great differences among mainstream schools and paradigms

[69] To the extent to which the practices of exclusion/inclusion within a spatially structured totality of sovereign states are dealt with, they remain an expression of the evolving and inherent philosophical contradictions of modern subjectivity – a never-ending political contradiction that is embodied, it seems inescapably, within the generic triptych of the individual, the state and the international system. "Kant's ambivalent articulation" as to whether the intractably connected pair of modern statehood and the system of states is able to resolve the tensions between particularities and universalities, notes Walker, "remains a crucial guide to the modern political imagination" (Walker 2010, p. 80). In other words, while international relations/IR are the quintessential arena of the sublime aporias intertwined with the unfolding *modern* organization of the body politic, there are no handy concepts to study how this logic unfolds through the reality of a technological-material world.

[70] One beauty of many feminist approaches, opposite to research concerned with state systems, is that they prioritize empirical field research and "lay-perspectives". Chapter 4 argues that this constitutes a methodologically promising route.

notwithstanding. Even incommensurable theoretical positions find common ground by conceptually externalizing or just neglecting the technological world. On close inspection, Waltz and Walker, in spite of their different appropriations and references to enlightenment thinking, have more in common than what sets them apart. Most important, the ongoing history of technological permeation of the real world is not playing any crucial role within their accounts. As proponents of science studies have pointed out (Winner 1995, Latour 1992b), to silence technology is a customary practice within all social sciences that are heavily indebted to logocentrism and excessively foreground the "social". Andrew Writes Feenberg (1999, p.2):

> "modern political theory subsumed technical activity under the economy and did not raise the same kinds of issues about rights and responsibilities in relation to it that are considered relevant to the state. Common sense instrumentalism treated technology as a neutral means, requiring no particular philosophical explanation or justification. So once again it was pushed aside; as an aspect of private life, it was considered irrelevant to the basic normative questions that concerned the thinkers of the great tradition in political theory such as Hobbes, Rousseau, and Locke (Winner, 1995)."

The Cartesian complex entails a logocentric structure at the ontological level that has led to the exclusion and, in fact, suppression of materiality. Technological artifacts, systems and infrastructures are barely visible within the basic description of the world that is familiar to IR. It is fair to note that the biased ontology of most IR schools' is not unique. One has to go no further than to "global transformation studies" to stumble over the same problem.[71]

[71] 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 take back even this cautious notice, by stating "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, p. 428) Besides a few comments on military infrastructures, *Global Transformations* does not dedicate a single page to the technological world. Samuel Huntington's *Clash of Civilizations* is another example. While Huntington critically notes that the expansion of the western civilization was owed to military superiority (1996, p. 51), he prefers to exclusively focus his line of arguments on culture, religion, and identity rather than relating it to technological connections.

4.4 The two faces of dualism: determinism and externalism

Aside from its logocentric ontology, the Cartesian complex entails another powerful element: conceptual dualism. The impact of Descartes' ideas comes in the form of an entrenched and self-evident distinction that sets apart politics/society and the material world (cf. Patomäki and Wight 2000). In the following, I discuss in detail literature that belongs to the two most widespread threads of dualism within IR; first, technological determinism and second, externalism of technology.

4.4.1 Technological determinism

Varieties of hard and soft technological determinism were a mainstream mode of theorizing international politics especially during the 1950s and the 1960s. These determinist or "substantialist" accounts do not resemble the crude materialism which is often wrongly assigned to Marx.[72] Determinists within IR rather assume that machines, weapons, and infrastructures, to a varying degree, can determine or shape actors, practices, and ideas in international affairs (Fritsch 2011). Especially, two groups stand out that have distinct theoretical views on technological innovations: Marxists and Realists. Marxist approaches generally understand the uneven distribution and ownership of production technologies as the central force behind world politics. For world system theories and the Dependencia school, the peripheral status of societies is predetermined by technological differences, and particularly by the asymmetric dependence on technologically leading economies (Cardoso and Faletto 1979). Hence, it is the control over and the access to cutting edge technologies that is a core determinant structuring the world system (Wallerstein 2004, pp. 28ff, Prew 2010, pp. 166ff.). While Marxists stress how the diffusion patterns of technological innovations privilege hegemonic centers at the core over the semi-peripheral and peripheral regions (Arrighi 1994), realist literature usually focuses on the effects of innovations in weaponry.

The constant danger of war dominates both the realist research agenda and its theoretical interests. Rapid advances in weapons systems are thought to have crucial

[72] See Bimber (1990) and Lawson (2007, pp. 33ff.). A more detailed discussion of determinism in in Chapter 2.

repercussions. Robert Gilpin elaborates how changes in technological environments alter state behavior, making it more or less expansionist. Apart from societal factors, Gilpin sees material advantages as underlying drivers of power politics. “Most frequently this advantage, especially in modern era, has been conferred by technological innovations” (Gilpin 1981, p. 54). Advances in transport and communication technologies have historically resulted in a “loss-of-strength gradient”, thereby massively changing the costs of exercising political dominance over large territories (Gilpin 1981, p. 56). He notes that innovations in military technologies also offer incentives for states to challenge the existing world order. For they imply a shift of the size of the area over which it is profitable to expand military protection in exchange for revenues (Gilpin 1981, p. 60). So, while novel weapon systems have played a decisive role in the advent of hegemonic wars within Europe, the global dominance of European empires owes its existence to technological progress. “The military superiority of Western civilization”, notes Gilpin, “has rested both on the complexity of modern technology and on the character of Western science-oriented culture” (1981, p. 61).

Elsewhere in the literature, realists assume that persistent weapon innovations constitute a general principle. The modern surge of technological inventions compels states to be permanently concerned with adapting and anticipating further progress (Buzan and Herring 1998). The “technological imperative” thus drives international affairs and especially national defense policies (Buzan 1987, p. 74). Exemplifying this point are the competitive logic by weapon types such as battleships in the 1920s (McBride 1997), the advent of strategic cruise missiles in the 1960s (Betts 1981), and the race for offensive cyber forces in the 2000s (Demchak 2003, Arquilla 2012). According to this view, waves of “military revolutions” have, over centuries, ushered in vastly different forms of warfare, defense policies and, ultimately, social and political order (Knox and Murray 2001, Hoyt 2003).[73] Anthony G. McGrew points out that the same mechanism combined with rapid industrialization in peripheral states led to a “the *globalization* of military innovation and to the emergence of a highly interdependent world military order” (1992, p. 84).

[73] This ties into the literature that sees a key role for warfare, military innovation, and defense organization in the context of modern state formation (see Porter 1994, Tilly 1985, Roberts 1995, Mann 1988).

> "The technological dynamic of the superpower arms race thus imposes itself on all states in the global system. It is in this sense that technology acts as a globalizing force – a force which not only structures the political relations between states but penetrates national societies across the globe." (McGrew 1992, pp. 84-5)

The nuclear revolution is perceived as the most pertinent showcase of how a new technology led to massive changes globally. Clearly, nuclear physics has essentially changed statecraft forever (Jervis 1989). For a period, different determinist arguments have been advanced. Numerous scholars and experts feared that uncontrollable advancements in weapon technologies were leading to shifts in the defense-offense balance. Observers anticipated that the political and military responses to nuclear standoffs would unfold in a destabilizing and uncontrollable manner (Freedman 2003). Thomas C. Schelling (2006, p. 50) reminds us that it was not exaggerated to believe that "unless the nuclear powers drastically disarmed, thermonuclear war within the decade was a mathematical certainty." Herman Kahn assumed that "a continuation of the present international order is incompatible with probable technological developments" (Kahn 1962, p. 209). Another group of scholars advanced to idea of "nuclear one worldism" (Deudney 1995). John Herz, for instance, theorized the political effects that the atomic age had on sovereignty and international system, anticipating technologically induced global interdependence. Herz assumed in a rather deterministic way the demise of the territorial state and the global "universalism", a view that he came later to correct and replace by a more complex understanding of the interactions of nuclear weapons and territorial statehood (Herz 1968, p. 13).

Drawing on these ideas, Daniel Deudney's "historical security materialism" conceptualizes the sequence of military revolutions on the systemic level. He introduces a reading of international politics as historically shaped by phases of technological progress (Deudney 2007). It links with reference to the critical engagement with modernity by early realists[74] the massive progress in the forces of destruction to different globally prevalent "modes of protection." Depending on certain historical states of military technologies, distinctive security practices are produced in the early modern, the global

[74] For the ethical and moral critique of technology by Morgenthau and other realists see Scheuerman (2009).

the industrial, and the planetary nuclear phase respectively (Deudney 2000b, Deudney 2000a). Deudney stresses the danger of misfits between the material context and actual security practices. He especially emphasizes that the security institutions of an anarchical international system seem insufficient for the nuclear age:

> “When violence capability is superabundant and rapid, the main real-state external security practice—balancing—requires special effort, and thus need no longer define security institutions. When violence is superabundant, security-viable politics no longer have to strain to mobilize enough power, but rather must de-mobilize power. Where superabundant violence capacity is available for extremely rapid employment, security requires enhanced checks on violence and on violence employment authorities that real-state practices and structures are unable to provide.” (Deudney 2000a, p. 96)

A somewhat similar approach is advanced in Duvall and Havercroft’s study on future space based weapons that might translate into an unknown form of domination. Their approach fits more the label of soft determinism than Deudney’s work. They study the “the constitutive logics“ of different yet-unrealized space-based weapon systems, and how their “modes of political killing are productive of political subjects.“ (Duvall and Havercroft 2008, 758ff.) They, too, come to far-reaching conclusions concerning the nature of the international system:

> “In the empire of the future the locus of authority is centralised but this authority governs a deterritorialised political entity. While this new constellation of political power will present new possibilities for resistance, we should not underestimate how this empire’s new modes of killing will constitute structures of domination potentially more terrifying than anything humanity has yet encountered.“ (Duvall and Havercroft 2008, pp. 774ff.)

To the extent to which determinist approaches make sense of technologies, their shortcomings have become apparent. Determinist studies on atomic weapons have led to paradox insights. The nuclear arsenals are said to have put more power into the hand of national armies than ever before while apparently ending the era of wars fought between major states (van Crefeld 1993, cf. Mueller 1989). In a much-quoted passage, Bernard Brodie (1946, p. 76) foresaw the radical impact of the “Absolute Weapon” in reversing the purpose of the military establishment from winning wars to averting them. But it took almost 20 years until nuclear weapons became recognized as making mutual nuclear deterrence the only game in town. The reason is that the material structures did not simply make superpowers realize that their overarching common interest lies in their nuclear dominance, non-proliferation, and stable deterrence (Walker 2000, Gavin 2012). In other words, the conceptual juxtaposition of the "material context" on the one hand and defense practices on the other is not fine-grained enough. It is unable to capture the sublime, fluid, and hybrid circumstances of technological systems and how they impinge on technically mediated human activities.

The limitations of determinist assumptions are most obvious from the fact that the political "results" of technological innovations become often highly contested. New means of transport compress time and space and facilitate economic interdependence (Gilpin 1981). But they can also turn into a force of peace, transcending the rivalry among states. Barry Buzan, for instance, claims that the idea of a "global society" and shared norms at the individual level presuppose high interaction capacities embodied in a "densely networked and interactive planet" (Buzan 1993, p. 339). Ferguson and Mansbach (2007, p. 534) argue that modern network technologies have caused a reduction of distances, which led to a post-international situation as "the product of simultaneous processes of fusion and fission of authority". The essentially contested political consequences of the Internet similarly undermine deterministic notions. In the debate whether cyber space is the utopian home of digital "liberation technologies" or rather the dystopian ocean of all surveillance techniques, it seems two techno-determinist accounts fight each other (Diamond 2010, Morozov 2011, see Drezner 2010).

Another debate among realists raises the question whether a fully modernized industrial society can still conquer another one. Against the "liberal" view that modernization has rendered military conquest obsolete, realist authors stress the crucial role of modern technologies for realizing effective coercion and repression.

> "... the rapid communication and mobility permitted by modernization allows conquerors to use their coercive resources efficiently. Communication links and technologies make surveillance easier. And since urbanization, roads, and mechanized forms of transport permit rapid and sequential responses to outbreaks of resistance, despots no longer have to distribute forces throughout their dominions." (Liberman 1993, p. 143)

The clash of mutually exclusive views demonstrates the principle shortcoming of determinism. The reason that determinist approaches fail is because they overly simplify the interaction between the "social" and the "technical" by merely assuming that social response just follows external material conditions. Determinist deductions, methodically speaking, preclude a careful empirical analysis of the historical *coevolution* of the practices, norms, and rationales in which artifacts and technological infrastructures are embedded in the first place. The development of military technology is subject to political choices and thus social nudging (Reppy 1990) as much as the Internet is. Madeline Carr (2011) shows that the perceptions of power, authority, and other normative priorities of US politicians have heavily influenced the legal and technical development of the Internet. In this sense, it "is essential to understand more about political interactions with Internet technology if we are to reach any useful conclusions about state power in the information age" (Carr 2011, p. 14).

To theorize technologies based upon rigorous theoretical deduction also produces sterile and abstract entities on both sides of the equation (i.e. the state, security policies, or the international system vs. "Technology" with big letters). In lieu of detailed empirical observations and historical sensitivity, the central weakness or determinist perspectives lies in their lack of differentiation ability. For example, the varieties of collective responses to different communication techniques from the printing press and telegraph to Internet-based social media remain unaccounted for (Mitcham 1994, Poe 2011). A differentiated theoretical treatment of how civilian and military technologies – not to mention their interaction and fusion – have stimulated diverging constructions of social order and political institutions therefore remains impossible. Analytically, determinists are not able to cope also with the competition among various military technologies: neither the technological imperative, nor security materialism can elucidate in general terms what actually constitutes the most relevant "material environment". While an increasing number of sophisticated cyber-weapons and robots adds to the existing conventional forces and nuclear arsenals, security materialism does not offer a conceptual operation to sort out the hierarchy between nuclear bombs, computer viruses and drones. In brief, IR's determinist approaches in their current form lead to a dead-end. Because they do not enable us to carefully theorize technological innovations nor to develop a sophisticated comprehension of “how machines make history” (Heilbronner 1994, p. 70).

4.4.2 Externalism

The majority of dualist approaches, however, takes a stance which is opposite to technological determinism. Their treatment amounts to *externalizing* technological innovations to a theoretically irrelevant domain, for artifacts and infrastructures are not seen as immediate elements of collective action and social agency. John Gerard Ruggie, introducing a 1975 special issue of *International Organization* on “international responses to technology“, exemplifies this conceptual move:

> “By introducing political purposes into the equation linking technological change to international organization we considerably complicate our descriptive and prescriptive tasks. International organization is itself then no longer a simple *response* to technology, but, rather, a more complex *product* of the intersection of two axes. Along the first is plotted the tensions between science, heavily informed by consensual knowledge of cause/effect relations, and politics, heavily informed by normative purposes, negotiated priorities and available capabilities. The outcome of this tension may be said to define the *situation* which science and its products will have occasioned. Along the second axis is plotted the tension between the need of states to respond collectively to problems and opportunities such situations contain, and their desire to maintain national autonomy and flexibility in so doing. The outcome of this tension may be said to define the response which a new situation will have occasioned.” (Ruggie 1975, p. 558)

Although the sociology of technology has long shown that actual “technological changes” do hardly resemble Ruggie’s picture, conceptualizing technologies as a *deus ex machina* still is representative for today’s mainstream research. It is assumed that the occurrence of technological innovation creates a new situation that, only then, becomes a tangible concern and requires social and political adaptation. Yet, the very existence of technologies implies numerous human choices were made earlier. And, as an inevitable part of the innovation processes, political and cultural forces come to influence and negotiate the shape technologies as mentioned above. Externalism, in other words, reinforces the conceptual separation of spheres: objective material facts and “collective decision making” must be strictly kept apart (Skolnikof 2002). Bruno Latour has called this conceptual trap the “great divide”. It purifies the messy emergence of technologies that entails divers entanglements between, and mutual transformations of, artifacts and social activities, ideas and norms from the first moment of innovational dynamics to their last step (Latour 1993).

Externalist approaches furthermore avoid studying the historical social-material complexity of technological evolutions. A range of authors divers as Gilpin, Strange, or Keohane seem to accept that innovation just happens. The emergence of technologies and related scientific discoveries seem self-evident and is taken for granted.[75] The nearly universal acceptance of this proposition is also a common tenet of classical economic theories (Aghion and Howitt 1992, Witt 2003)—and here compartmentalization and externalism are mutually reinforcing. This explains why most theoretical frameworks in IR and IPE conceptually silence innovation processes. So, while the “externalists” at least indirectly touch upon technological innovations, their research focus is directed towards “political” struggles over interests and values attached to technological innovations.

Contrary to determinism, externalist conceptualizations tend to instrumentalize technologies. Most scholars consider technologies as resources to be applied in power struggles or diplomacy. According to this widespread view, technical expertise and technologies can be deliberately manufactured to serve as a resource yielding to the purposes of politicians or generals. Neorealist and neoliberal schools as well as constructivism share this instrumentalist view (Singh 2002, pp. 6-12). Constructivist analysis in particular insists on the centrality of ideational puzzles for explaining international affairs (Wendt 1992, Onuf 1989). Consider Adler’s (1997, p. 336) statement that remains largely uncontested among IR scholars: “social reality is a matter of imposing meanings and functions on physical objects that do not already have those meanings and functions”. In this instrumentalist vein, numerous studies of weapon technologies study the meaning attached to objects such as nuclear bombs or chemical weapons, and technological progress more generally, to show how actors endow materials with social meaning (e.g. Adler 1987, Price 1995, Solingen 1996, Suttmeier, Tan, and Yao 2006). As “material” and “ideational” factors are seen as irreconcilable,

[75] For a more detailed comparison how the big IR schools treat technology according to their logic see Fritsch (2011).

materials have no meaning, as it is merely an instrument of social actors. To cite Wendt at length:

> "Material power is only "power" insofar as it is meaningful, as shown by the relative threat to the U.S. posed by 5 North Korean nuclear weapons versus 500 British ones. And interest is only "interest" insofar as it is given content by ideas, as shown by the U.S. failure to conquer the Bahamas. In each case, realism's ostensibly material factors turn out to be constituted largely by ideas; at best we are talking here about how one set of ideas ("realist" ones, perhaps) relates to another ("idealist"). (…) the only fair way to compare the relative importance of ideas and material conditions would be to first strip power and interest of their constituting ideas, isolating their brute or rump materiality (technology, geography, and human nature), and then seeing to what extent the latter constrains or causes the former. Were we to do this in IR, however, with its non-material corporate actors interacting in a space of shared meaning, it seems clear that ideas would be more important." (Wendt 2004, p. 54)

Although coming from a different theoretical perspective, scholars who explore epistemic communities similarly downplay the "material" side.[76] It is suggested that expertise embodied by epistemic communities shapes international environmental treaties, regional integration, nuclear disarmament, and global governance in general (Haas 1992, 2004, Hajer and Versteeg 2005). Yet, the actual subject matter which gets represented by scientists – such as "environmental change", "sustainability" or "technical systems" (e.g. Sandholtz 1993, Detraz and Betsill 2009, Dingwerth and Pattberg 2009) – remains conceptually neglected because materials are usually seen as mute (Mayer 2012a). Ruggie's proposition of 1975 again is symptomatic for the role assigned to technology:

> "Physical and technological parameters are important determinists of international

[76] Peter M. Haas was most influential in bringing science to the minds of a broader academic audience. He advanced the concept of "epistemic communities", what he defines as a network of professionals that articulates "new knowledge (...) a state may elect to pursue entirely new objectives" (Haas 1992, p. 4). This approach assumes that knowledge is powerful because it influences the framing of problems, international decision-making processes, the definition of state interests, and fosters international policy coordination based on consensual scientific knowledge. Exploring the emergence of international cooperation and regimes, Haas directs his spatial focus at the nation state, whereas his primary actors are epistemic communities and individual states. For Haas knowledge can reduce uncertainty among rational actors in the context of a moral hazard problem. It further brings about convergence of national interests through a common definition of recognized problems and possible solutions as for instance to environmental pollution (Haas 1992).

> responses to technology when those responses concern research, scanning and monitoring, and problem recognition in general—when, in a word, the issue is to *discover* or *understand* some process or situation. When, however, the issue is to *manage* some process or situation, the weight of political purposes becomes preponderant." (Ruggie 1975, p. 558)

From externalizing materiality, however, arises serious conceptual inconsistency, especially for constructivist theories as Herrera, who notes:

> "the objective conditions in this conception of the international system function just as the material environment does for neorealism – as a background condition that constrains but does not force states to adapt. So if shifts in the underlying technologies of communication, for example, should increase the objective amount of interdependence in the system, then technology would be a *deus ex machina* again driving systemic change and not one that can be accounted for by the theory. This is a curiously anti-constructivist conclusion to arrive at for a supposedly constructivist theory of international politics." (Herrera 2003, p. 569)

Yet, accusing Wendt for not being constructivist enough misses the mark because he merely reproduces the preexisting logocentric conventions. Regardless whether from realist, liberal, or constructivist schools, numerous authors see technology only as external driver or factor (Buzan and Little 1993, Skolnikoff 1994, Keohane and Nye 1998, Rodrik 2008). It is not regarded as essential part of the social fabric. Wendt plunders rationalist concepts such as "interdependence" (Keohane and Nye) or "interaction capabilities" from advanced system theories (Ruggie and Buzan) to make sense of technological change within his own theory (Wendt 1999, pp. 243-249).[77] Through treating (technological) interdependence as an under-specified "master variable", *Social Theory* consequently renders technologies external to a purely social system.

Even IR scholars who acknowledge that the relevance of technology is not well captured by notions such as "rump materiality" fall short of assigning substantial theoretical relevance to it. Regime theory is a case in point. At first sight, it responds to the growing technological interconnections and increased trans-boundary flows between nations (Keohane and Nye 1971, 1977) but than moves quickly to the social interactions.

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[77] For a systematic overview about Wendt's borrowings from Neorealism and Neoinstitutionalism see Guzzini and Leander (2004) and Kratochwil (2000).

We should pause at this point to appreciate the parsimonious beauty with which Robert Keohane's *After Hegemony* treated the highly complex and globe-spanning operations of production, trade and usage of crude oil—the material underpinnings of what should come to exemplify "regimes" (Keohane 1984). To the extent to which his work succeeds in boiling down everything to a coherent set of assumptions (collective actions problems given certain transaction costs), it represents a tremendous achievement in the art of abstraction. Overtaking Waltz's puzzle—state action under anarchic conditions—Keohane later maintains that "institutions for global governance will need to limit the negative externalities of decentralized action." For he thinks interdependence "provides opportunities for actors to externalize costs of their actions onto others." (Keohane 2001, p. 2)

The intriguing complexity and connectivity of the technological world is, to put it differently, turned into an issue of "beggar thy neighbor" while the design of institutions—formal and informal sets of rules and norms—remains a political issue without any material substance. Even the theoretical transmission belt between the strategic choice within or through institutions and a messy interdependent world – "transaction costs" – is mainly understood in social or cultural terms (see Aspinal and Schneider 2000). Related theoretical approaches such as neofunctional and institutional integration theories, issue linkage, interdependence theory, or regime complex theory similarly see technologies as external to institutions and collective bargaining.[78] In brief, rationalist frameworks essentially frame technology as a neutral tool that merely creates or solves problems. It is thus either a concern for the assertion and deliberation of collective social (state) interests or can easily get paired with a material understanding of power: "Knowledge", write Nye and Owens (1996, p. 20) "more than ever before, is power".

The English school offers the final example of externalization. While Watson acknowledges the central role of military innovations and industrialization for the

[78] See e.g. Haas (1968), Rosenau (1969), Keohane and Nye (1971) Haas (1975, 1980), Aspinal and Schneider (2000), Pollack (2001) and Raustiala and Victor (2004). Another example is Karl W. Deutsch's work on the effects of emerging transnational communications in the 1950s—a precursor to the research on international interdependence. One finds here similar externalizations of communication media, while the "content" represents the core theoretical and empirical research interest (see Deibert 1997).

expansion of the European International Society (1992, p. 268), it was Barry Buzan who has seriously tried to grant technologies a substantial theoretical role in the context of neorealist-structural approaches. Through changes in the "interaction capacity", he argues, does technological progress affect the properties of a specific international system. This explains than the historical variety of systems—an empirical fact which is omitted by Waltz and others who foreground "like-units" to the effect of denying the existence of several types of differentiation (Buzan 1993, Buzan, Jones, and Little 1993, cap. 4). But Buzan's still merely sees battle ships, telegraph cables, or transport infrastructures as "driving forces" that from the outside push the differentiation of international systems or societies (Buzan and Albert 2010, p. 333). The sheer increase in "interactions capacity" and the notion of time-space compression, which are used in IR to abstractly describe the effect of modern technologies (Walker 1993, Ferguson and Mansbach 2001, Buzan and Lawson 2015), cannot explain in detail why and where the great divide had occurred (see Chapter 2). As Buzan's interest remains primarily focused on state/society-interactions and modes of power, technological innovations are taking on a residual explanatory function. They are construed outside and prior to a *social* system consisting of primary and secondary institutions.

In sum, the dualistic component of the Cartesian complex provides an additional explanation of IR's neglect of technologies. On the one hand, technological determinism offers over-simplifying frameworks unable to capture the complexity and dynamics of innovation processes. On the other hand, externalism renders technology a *deus ex machina*, placing it both outside of history and outside to the theoretically relevant realm. Interestingly, constructivist and rationalist approaches employ a similar externalizing strategy. To phrase it differently: the analysis of the Cartesian complex reveals a common blind spot of seemingly conflicting theoretical approaches. For this reason, the complex life of cars, mobile phones, chemical factories, power plants or archives occupies a no-mans land in between the "material"—objective facts, capabilities or irresistible force—and the "ideational"—subjective purpose, social meaning, or rational interest. Externalist approaches do not just legitimize instrumentalism and reinforce the ontological bias towards rational choice and inter-subjectivity.[79] The consequences of dualism also have largely detached IR's comprehension of technologies based on empirical field research. Determinists do not offer a better recipe in this regard.

4.5 Coproductionist approaches

The two faces of dualism reinforce the fallacy of logocentrism by preventing a conceptually differentiated and empirically sensitive exploration of the global politics of technological innovations. As the observations in Chapter 2 and Chapter 3 have shown, dualist approaches are unsuited to study technological innovations. It is therefore unsurprising that many IR studies which touch upon technological innovations run into paradoxes – researchers lack sensitive conceptual tools to develop puzzles and questions that display a recognizable resemblance of the technological world.

This problem, of course, has not gone unnoticed and theorists have begun to look for solutions. One such approach is to find a better "balance" between ideational and material factors (e.g. Wight 2006, Deudney 2000a, Poliout 2010). Given the discussion above, it must be noted however, that attempts to "balance are not convincing because they ultimately reproduce dichotomist theorizing. Another idea is to articulate a "middle ground". Yet, as Herrera states, "placing oneself there should be done with care." The problem of "middle ground" approaches is that they "too easily become vague and insubstantial" (Herrera 2003, p. 576). Herrera's own work on technological innovations and world order (2003, 2006), pinpoints the crucial issue. There simply is no "middle ground" that resembles a convergence or complementarities of the two ideal-types of "determinism and social constructionism", as he argues (2003, p. 576). Just blending to seemingly separate worlds—reconciling the domains of reality that have been separated so carefully by Cartesians—is tantamount to self-contradiction. The limits of IR theorizing arise where scholars attempt to blend the seemingly separate social/material worlds. If middle ground means to take an analytical position between a purely social and

[79] We understand by now why, if particular technologies are nevertheless addressed, this typically happens in an odd "ad hoc" manner (Herrera 2003, p. 565) – of which Kenneth Waltz's famous assertion, that "the longest peace yet known rested on two pillars: bipolarity and nuclear weapons" (1993, p. 44), is an excellent illustration.

a purely technical world we would perpetuate the illusion of the "great divide". Merely adding up social/material dichotomies or meshing together two inadequate notions does not produce an improved conceptual framework.

Instead, a viable conceptual language is capable of fusion or hybridization between the "material" and the "political", the "technical" and the "social" as technological innovations often leave nothing unaltered. "The realities of human experience emerge as the joint achievements of scientific, technical and social enterprise" writes Sheila Jasanoff (2004a, p. 17), thereby questioning the conceptual appropriateness of prefixed agents, structures, or practices. Approaches that analyze "coproduction" focus on the nexus of society, nature, technology and science. Jasanoff distinguishes between two main varieties of coproduction: interactional and constitutive. The first group explores the interactions, boundary conflicts and entanglements among prior fixed entities, groups or processes such as social practices and technological artifacts. The second sheds light on the emergence, stabilization, and evolution of previously not existing things, groups, or practices such as scientific fields, objects, or technological systems. So, while interactional accounts carefully analyze the human activities, social practices or institutions interaction with scientific expertise or artificial objects without relying on social reductionism or determinism, constitutive accounts focus on intermingling of all "domains" at the point of emergence and stabilization of the building blocks of human societies (Jasanoff 2004a, pp. 19-22). In short, coproductionist scholars conceptualize innovations either in a manner that challenges the idea-matter dichotomy or erase these categories altogether (see figure 3.1).

By applying a coproductionist lens one can divide the IR approaches to technological innovations, which go beyond externalism and determinism, into two groups. One group deals with the question how *established* practices or principles such as sovereignty, state authority or foreign policy are challenged by technological changes or scientific knowledge (Litfin 1997, Skolnikoff 1994).[80] This literature comprises the examination of the consequences of the digital revolution and information technologies for the regulatory capacity, governance ability, and legitimacy of nation states (Mowlana

[80] The impact of technological shifts on statecraft already was concern in earlier (see Deutsch 1957, Morgenthau 1964).

1997, Rosenau and Singh 2002, Drezner and Farrell 2004, Drezner 2004, Eriksson and Giacomello 2009). Other research asks how “national security” is affected by the emergence of data networks, cyber weapons, and cyber space in general (Eriksson and Giacomello 2006, Grobler and van Vuuren 2012) and how the conduct of warfare has changed through digital technologies (Cullather 2003, Halpin, Trevorrow, Webb and Wright 2006, Deibert, Rohozinski and Crete-Nishihata 2012, Manjikian 2010). In addition, scholars aim at reframing the realist concept of “power” to accommodate to the information age (Keohane and Nye 1998, Nye 2004, Mayer 2012b). The Internet, at the same time, has become the crystallization point for both hopes about the influence “technologies of liberty” and fears of tools of suppression, control, and censorship (Deibert 2000, Warkentin and Mingst 2000, Boas 2004, Mueller and Chango 2008, Deibert and Rohozinski 2010, Diamond 2010, Drezner 2010, Mueller 2010). Perhaps the most systematic approach is Dan Deudney`s (2006) theorizing of security materialism which links the macro-level of security practices to the evolution of weapon systems.

Although all analyze the interplay between the “technical” and “social”, different authors put different emphasis on the respective sides of this equation. However, where “inter-state” are relations selected as units of analysis, as it is here mostly the case, this leads to odd, yet, widely accepted vantage points to image research puzzles in which material objects such as satellites, strategic missiles, monitoring systems, super-computers, or simulation models, then, still appear as *deus ex machina*. Accordingly, sterile “technology” gets juxtaposed to equally sterile concepts of “sovereignty”, “national security”, or “international relations”. This literature, by and large, is restricted to a few aspects of what would be potentially relevant when we approach the transformative effects of technological innovations. The authors advance puzzles that construe an interaction or influence between pre-given concepts such as “the state”, “power capacities”, “society” or “national security” on the one hand, and certain technologies or rather often technology in general on the other. To the extent to which this sort of interplay leads to satisfying questions and puzzles the inherent perspectives are narrow in scope. While these approaches make the massless conceptual framework of IR a little “rasping”, they mostly remain tied to the conceptual straitjacket of the Westphalian System. But, as we have already seen above, it is exactly this sort of conceptual framework, which is poisoned to produce paradoxes and dead ends when confronted with technological dynamics. It follows that the analytical stress on the interplay of fixed entities is somewhat misplaced. By appreciating the empirical evidence presented in Chapter 2, and knowledge of science and technology studies in particular, the problem of "interplay" that is typical to the above mentioned approaches is obvious.

This brings us to the second type of coproduction, which is the most promising. While it accounts for the *emergence* of new structures, actors, practices, identities, it zooms in at the politics and sites of contestation, resistance and negotiation (Luke 1994, Barry 2001, Flyverbom 2011, Whatmore 2009, Home 2010). As such, Sheila Jasanoff's exploration of the "biotechnological empire" and Karen T. Litfin's analysis of space technologies are extraordinary. Litfin shows how satellites, being a technology of surveillance, have socialized a global gaze that made possible arms control psychologically and technically. At the same time, this military dominated technology has given rise to a plethora of non-state actors, which use images or real time footage to reinforce environmental protection or monitor human rights (Litfin 1999, 2002). Ultimately, Litfin retains a state focus, whereas Jasanoff unearths with notable theoretical rigor a vast structure that reaches across national boundaries tying together human bodies, metropolitan lifestyles, peripheral agricultural practices, national security policies, high-tech science, and profit strategies of large multinationals (Jasanoff 2005, 2006). Similarly, Andrew Barry and others (2001, Barry and Walters 2003, Bellanova and Duez 2012) demonstrate that the technological fundament – including infrastructures, networks, zones – although getting almost no attention from analysts of the European Union, is particularly critical for the success and trajectory of European integration.

A few studies have seriously tried to tackle the *contingent* relationship and the *heterogeneous* intertwining between the proliferation of material artifacts, extensive use of technological infrastructures, and group formations in a manner that goes beyond conceptual reenactments of the "great divide" between the political and the technological (see e.g. Buzan and Lawson 2015). For example, Rosenau's brilliant *Distant Proximities* shows that new actors, social constellations, and political connections emerge through global technological processes (Rosenau 2003). But, his work does not suggest a more systematic view on the unit of analysis problem. In addition, he conceptually maintains a marked distinction between the social and technical domains, clearly granting the former preponderance. Strange's work (1988, 1996) addresses the delicate state of epistemology of technological innovation: The blurring of the taken-for-granted lines between "security" and "economy", which Strange stressed as the signature gesture of the field of IPE. Today, contradictions of the analytical clarity of IR's conceptual language is perhaps nowhere more obvious than with respect to telecommunication and cyber-technologies (Deibert 2013, DeNardis 2014). For instance, the immense digital infrastructure of the US constitutes a thriving private-public partnership based on Evgeny Morozov (2013) calls "a social contract between Silicon Valley and Washington". Yet much of the research on the Internet overlooks the crucial physical infrastructure and, more importantly, the evolving intersection of the virtual and the physical (see Stevens 2012). In short, even some coproduction approaches fall back into dichotomist thinking.

Another major example for the ambivalent effects of new technologies is the connection between nuclear weapons and weather monitoring. Because the cold war was conceptualized as "global struggle, reading all conflicts everywhere in the world as part of the contest for military and ideological advantage (…)", notes Paul N. Edwards, "military technological change also increased the superpowers' appetites for global weather data and forecasts. (…) Tactical nuclear strategy depended on knowing the likely path of fallout clouds and the distances they might travel on the wind." (Edwards 2006, pp. 242-243) However, rather than deepening international conflict lines, "geostrategy and technological change", paradoxically, "aligned military interests with the informational globalism of scientists" (Edwards 2006, p. 243). The exchange of monitoring weather data went on nearly uninterrupted during the Cold War while collaborative efforts to simulate weather and climate eventually transformed the understanding of the earth.[81] Today, the enormous influence of the scientific ensembles—

[81] Moreover, while the US army waged weather warfare over Vietnam, Laos and Cambodia between 1967 and 1972 (Flemming 2007, p. 55), computer models that showed the planetary consequences of nuclear explosions provided increasingly sophisticated simulation of the global climate system. The crucial lesson was that all nations depend on intractably interconnected ecological systems—the climate and the atmosphere just being one among others. The "consequences of a nuclear war", warned Carl Sagan (1983) in *Foreign Affairs* "could constitute a global climatic catastrophe". Nuclear weapons and climate science have a history intimately intertwined. In a twist reminiscent of Einstein's commentary, their confluence led the international spread of consciousness about planetary fragility on the one hand, and to legitimizing

consisting of data collection technologies, computer models and shared expertise, international research bodies—is best exemplified by the IPCC. Its ability to assert global political changes is indicative for the contested removal of power from governments to international scientific organizations (Edwards 2012).

The co-productive set of approaches also ties into the growing concern with complexity and hybridity of agential forces within IR and historical global studies (see Urry 2007; Youngs 1999, Chudworth and Hobden 2013). This has two major consequences. On the one hand, the sensitivity for the ambiguity of technology and its multipurposeness is growing. In contrast to determinist assumptions, the political results of technological innovations remain—despite immense efforts put into simulations and scenario building—*underdetermined*. This is not only due to the mostly unknown socio-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; Teschke 2014). On the other hand, coproduction calls for amore sophisticated articulation of the agency-structure problem and new forms of power. STS and geography scholars have illuminated how 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 (Bijker et al. 1987, Latour 1987, Whatmore 2002, Dittmer 2014). Research from fields such as security, energy, environment and elsewhere, drawing from coproductionist accounts, illustrates that agency is increasingly enriched by ensembles, actor-networks, and non-human actors.[82] These studies do no longer grant the unified actor "state" a central analytical place. In this line, JP Singh's idea of "meta-power" articulates a form of influence that emerges through information technologies but outside the classical confines of states (Singh 2013, see also Ansorge 2011).

The interweaving of technology and social practices creates a hybrid world in which the neat separation in human and non-human is often challenged and undermined. This is most discernible in the military. Der Derian (1990) argues that chrono-politics

"technocratic futurology" and earth system management on the other hand (Ross 1991, p. 14, Edwards 2012, Miller 2004).

[82] See e.g. Aradau (2010), Mayer and Schouten (2011), Squire (2014), and Salter (2013).

have unleashed forces which essential transform the spatial and temporal aspects of international politics.

> „Space is no longer primarily territorial in the late-or postmodern condition. Geographical space has been considerably challenged by the triad chrono-cyber-hypertransparent space. The latter provokes geospace by understanding distance in terms of time rather than geography, by substituting hyperreal, simulated space for real space, and by radically disclosing a wellshaded space. The forces of production—speed, simulation and surveillance—of the challenge create new forms of estrangement while simultaneously mediating these estrangements.“ (Huysmans, 1997, p. 376)

At the same time, technological innovations in warfare have produced semi-autonomous machines, semi-cyborgs, and human-machine combinations that are connected on the battlefields and with the command centers back in the military headquarters. This has brought about profound and unforeseen change in surveillance, warfare, and power projection (Dillon 2003, Der Derian 2009). As a result, the boundaries between war and peace, the domestic and the foreign, humans and non-humans are becoming increasingly blurred and indistinguishable (Singer 2009, Stroeken 2013). Antoine Bousquet, employing a Foucauldian approach, shows how 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, creating distinct types and discourses of warfare (Bousquet 2009). The idea of "becoming" is also animating Der Derian's work military revolutions:

> "As the infosphere engulfs the biosphere, as the global struggle for 'full spectrum dominance' supplants discrete battlefields, as transnational business, criminal, and terrorist networks challenge the supremacy and sovereignty of the territorial state, information warfare has ascended as a significant site for the struggle of power and knowledge. Infowar wages an epistemic battle for reality in which opinions, beliefs, and decisions are created and destroyed by a contest of networked information and communication systems. (Der Derian 2003, p. 452)

While this kind of empirical field research on was for a long time relatively rare in IR, it is based on an under-conceptualization of technological innovations. Der Derian, who depicted the confusing networks of global high-tech warfare, deliberately chooses "to avoid the vices of academic abstraction" alongside, as he apparently notes with irony, with Pentagon propaganda and journalism (2009, p. xxxvii). It is not really surprising, thus, that mainstream theories were unable to adopt these perspectives.

4.6 Summary: dead-ends and bridges

This review illustrated that technological innovation constitutes a marginal research topic in IR. While central in the 1950s and 1960s, it has faded from the mainstay of the discipline both, as an empirical and theoretical concern, only to return quite recently. To summarize, the differences among the great schools and paradigms notwithstanding, even incommensurable theoretical positions find common ground by conceptually externalizing or neglecting the technological world. The history of technological permeation, composition, and remaking of the world largely is missing within these a-historical accounts. Ad hoc accounts remain under-theorized. Obviously, the politics of technological innovation does not merely resemble competition among national economies; it can not be boiled down to the "great game" for global power and influence; it does not constitute a power-seeking strategy for late-developing countries; even less so does it make sense to place technological innovations under the trusteeships of "soft power"[83]; it is furthermore not plausible to reduce the international technological catch-up merely to a matter of perceptions or meaning; neither does the conviction merit attention that actors attach "meaning" to technological artifacts that, in turn, are powerful carriers of identity.

This review also has proposed that this omission is due the to operation of the Cartesian complex in IR. Logocentric ontologies, the compartmentalization of knowledge, and the practice of dualism leading to determinism or externalism have all contributed to the marginalization technological innovations. However, this mapping exercise has not yet sufficiently resolved the puzzle how technological innovation, an

[83] This may appear attractive for studying communication technologies and cultural exports via entertainment industries though (see Nye 2008, p. 101).

issue that has become of utmost importance for economists and politicians, could become silenced IR and IPE (see more in 5.1). Still, we were able to figure out central research desiderata. While many determinist studies on certain technologies deliver fascinating accounts they are less convincing in terms of their theoretical frameworks. Moreover, this review has also identified alternative approaches that have seriously tried tackling the contingent relationship between the proliferation of material artifacts, the extensive use of technological infrastructures, and political formations in a manner that goes beyond reenactments of the "great divide".

The zone of coproduction is the most promising way forward although limitations remain. First, theorizing. The manner in which Herrera (2003, 2006) develops his approach to "socio-technological" systems is informative in this respect. Although clearly embracing a coproductionist stance, his hybrid perspective is representative for many other less careful conceptualizations. It derives, ultimately, from the *deductive* manner in which the theoretical place of technology in IR theories is usually contrived of. Consequently most conceptual frameworks do not hold against the complex empirical record presented in Chapter 2. The notable outliers who avoid treating the subject matter deductively appear to make a telling *methodological* case. Even though Der Derian deliberately waters down theoretical ambition—for good reasons—his research reveals how meager, in the first place, the substance and legitimacy of these "abstractions" actually is. In addition, it shows that simply *applying* ready-tailored concepts from other disciplines leads one into similar analytical contradictions as ad hoc subscriptions to technological "aspects" of international relations. In this sense, approaches that cling to deductive, theory-driven methodologies are not successfully grasping the dynamical nature of progressive waves of innovation; nor do the seamless webs, connections, and translations among different actors, which are so emphasized by historians of technology (Galison 2006, Hughes 1994), make it into their texts.

Second, researchers on technological innovations largely missed to engage in a debate amongst themselves. No collective theoretical advancement has occurred. One must admit that these explorations are complicated by the fact that no research field exists. Their empirical work and conceptual efforts have remained isolated pieces. The knowledge, by and large, was not shaped through conversation with each other but often pressed into the conceptual straitjackets that belonged to other topics, domains, or debates. The coproduction approaches in particular have failed to systematize their insights in order to feed back into mainstream theoretical debates. Given the general lack of deep theorizing within the coproduction zone and the absence of a broad range of *different,* respective theoretical views, I argue that we should look more intensively beyond disciplinary borders.

Third, as technology just experiences its return as a topic in IR, perhaps the biggest shortcoming of the works that have explored the role of technologies lies in their common neglect of STS and innovation studies. Few authors have drawn their inspirations from the decades of studies on technological innovations.[84] In short, to make sense of technological innovations—how they relate to the transformation of power and international affairs more broadly, i.e. to theorize it in a way that speaks to IR and IPE—we must draw on research about innovations from fields such as history, economics, comparative politics, and STS.

[84] This is the case for a great variety of studies about technological innovations stemming from different disciplinary angles such as cultural studies, anthropology, philosophy, economics, geography and ethics. See Kaplan (2004).

5. A brief archeology of the onto-politics of lightness (interlude II)

Is there a deeper reason for the lightness of IR? In Chapter 4, the discipline's lack of interest in technology was explained with the operations of the Cartesian complex, which prevents researchers from capturing the evolutionary drama of technological innovations. But by focusing on the restrictive ontological parameterization and the problems of technological determinism and social reductionism, we only began unpacking this puzzle. The following interlude assumes a reversed logic: the absence of technological innovations is not accidental but intimately linked to both IR's general meta-theoretical commitments and its conceptual matrix. To substantialize this assertion, we need to probe into the related "onto-politics" of practical entanglements, that is, to contextualize the deeper strata constitutive of the Cartesian complex of IR.

William Connolly used the term *onto-politics* to indicate that every interpretation of the world rests on certain ontological assumptions. All knowledge "contains fundamental presumptions that establish the possibilities within which its assessment of actuality is presented" (Connolly 1992 cited in Campbell 1998, p. 504). For our purpose, onto-politics bear a slightly different meaning. As explorative realism replaces the subject-object schema with a continuum between stable and unstable knowledge (see chapter 6), the nexus at which epistemology and ontology converge are *scientific practice*s.[85] A praxiological understanding of IR (Ashley 1988, Bueger and Gadinger 2014), than, has two critical implications: firstly, it requires not only a history of ideas but also a sociological perspective to explain the birth of IR's lightness. To examine the latter's onto-politics involves not only conceptual layers and epistemological considerations but also other contextual factors and relations, rendering the non-ideational connections and interventions visible that partake in research and are shaping its results. Secondly, it calls into question how we currently understand the limitations of knowledge production in IR. I argue that the comprehension of both what and how we can know, given the shape of methodological apparatuses (see Aradau and Huysmans 2014), remains in the grip of a

[85] Connolly's definition is based on an understanding of epistemology and ontology, which need to be modified for explorative realism. He foregrounds the shaping of knowledge through interpretative lenses (epistemology) over the existence of entanglements, that is a reality without "positivist" observers (ontology).

Cartesian confinement despite the conceptual nuances and theoretical diversity existing within IR.

5.1 From unproductive dichotomies towards a sociology of knowledge

Why is IR's ontological monoculture so persistent? Why does it seem so plausible to perpetuate the discipline's lightness? My thesis is that there is a blind spot at the center of the meta-theoretical self-reflection of IR scholarship. Consider, for instance, Collin Wight's treatment of the methodological state of the discipline. After four, according to others accounts five, "great debates", the fundamental philosophical divide between hermeneutics and positivism has only been reinforced. Although the discipline increasingly draws on the philosophy of science, and the framework of contemporary IR, as Wight notes, "bursts at the seams". A dichotomy of orthodoxies still structures knowledge production: On the one hand, according to Wight, we find the cluster of "explanation", "positivism" and "rationalism" indebted to a Humean tradition. On the other hand, we are confronted by the grouping of "understanding", "post-positivsm", and "reflectivism". "Constructivism" proclaims, unwarranted as Collin correctly notes, to occupy the distance in between those two poles (Wight 2002, p. 36).[86]

This unity in disunity points to another chasm, which is as crucial as the epistemological division: the fundamental distinction between dualist and monist understandings of ontology (see Wight 2006, Jackson 2011). Wight reminds us that because of the "tribal" dynamics related to these positions, it is difficult to move beyond the current impasse:

> "Unable to shake the positivist orthodoxy because it never really understood it, the discipline simply poured the newly emerging patterns of thought into the old framework. But, as any mathematician could testify, a 'thousand theoretical flowers' into two will not go, and hence the current framework bursts at the seams. Simply adding a new 'middle ground' category does not help and nor does subsuming a range of differing categories under one label. And so the current framework 'disciplines' and demands that one declares one's allegiance. Once declared, one's analytical frame of reference is specified and one's identity firmly fixed. As a rationalist you *will* privilege material factors, causation and

[86] Hollis and Smith (1990), Keohane (1988), and Adler (1997) advanced similar dichotomies.

science; as a post-positivist/reflectivist you *will* privilege ideational factors, deny causation and are (sic) anti-science. Any attempt to challenge this categorization is tamed and forced into one or other extreme. This is exactly the reaction from both sides of the divide to Wendt's attempt to occupy the middle ground. The idea that one has to declare which tribe one belongs to and that this determines one's ontological frame of reference, epistemology and appropriate methods seems a bizarre way for a discipline to proceed. (…) These objections notwithstanding, and given the long history of the discipline's attachment to this framework, its rejection looks unlikely." (Wight 2002, p. 40; italics in original)

Although Wight's description is sharp-edged and comprehensive, it is itself articulated in a Cartesian framework. Importantly, it does not explain how the framework of IR, on the one hand, has evolved by silencing the strong materialist currents of thought in the early twentieth century (see Deudney 2007), and on the other hand, has long hindered the incorporation of additional subject matters and methodologies such as the corporal or the material turn in particular (see Salter and Mutlu 2012, Kirsch 2012). The relationship between the usage of the philosophy of science and the exclusion of alternative research puzzles and empirical domains, that are concerned with the material world in general and the modern technological developments in particular, remains unexplored. Wight's depiction of the meta-theoretical framework of IR cannot offer explanations why IR fails to capture materiality. One reason is that Wight views IR through a thoroughgoing lens of dualism (Jackson 2013).[87] To mitigate these problems, Patrick T. Jackson suggested an elegant solution in form of a four-fold typology of philosophical ontologies based on Weberian ideal types. This model also introduces a different understanding of meta-theoretical commitments (Jackson 2011). While, the idea of "ontological wagers" are productive in thinking about scientific status of knowledge diversity in IR, Jackson once more privileged the epistemological and ontological divisions over methodological issues (Aradau and Huysmans 2014).

Jackson's failure to capture the full extent of IR's lightness is suggestive for the IR community at large. The reasons for the methodological debate not to catch fire are plenty. For instance, Wight assesses how IR theories employ the philosophy of science without considering parallel or diverging developments in other disciplines. Susan

[87] See, for instance, Wight's misunderstanding of Jackson's philosophical ontology (Jackson 2013).

Strange has energetically opposed this isolated form of introspection as she emphasized that the reflection about the notions and assumptions of *different* academic disciplines is absolutely necessary to uncover blind spots and mutually unrecognized default positions. The lack of systematic inter-disciplinary communication, in turn, leads to a selective ontology and biased research and policy prescriptions (Strange 1970, Strange 1988, pp. 12-15). Moreover, Wight's narrative only takes recourse to ideas and concepts. He does not consider research *practices*, and, therefore misses central aspects of the story of knowledge production by IR. Practices, however, involve a lot of additional things; things that the researcher has to assemble in order to establish the scientific authority of his/her theoretical claims as well as their empirical validation and epistemic plausibility. The practice of research also entails instruments, pictures, figures, archives, disciplinary costumes, university institutions, publications requirement, concepts, notions, data storage, and simulation devices (Latour 1987); and, equally, the use of narratives, metaphors, story telling and myth making (Weber 2005).

In order to move beyond Cartesian dichotomies and to explain, in particular, why IR has eschewed technological innovations, we have to deepen our understanding of the IR framework. A different key, that combines tools from the philosophy and science and the sociology of science, is needed to crack the puzzle of the discipline's lightness. My suggestion is to unearth the relationship between certain theoretical notions that became common sense in IR on the one side, and the interplay of the disciplinary identity in the making and emerging research practices on the other. A comprehensive exploration, obviously, would require a rigorous disciplinary "archeology" of how IR has treated technological innovations from the 1950s to 1990s. This task is beyond the scope of this short intervention.

5.2 The stag-hunt allegory and the purpose of unmediated relations

My entrance point is, once again, Kenneth Waltz's work *Man, the State, and War* (1959) because I assume that it played a central role in shaping and stabilizing the "Cartesian complex". In particular, I shall take issue with the question as to how the marginalization of technologies relates to the introduction of a set of ideas including the "three images" and the "international system" as a unitary actor model, which undoubtedly became obligatory passage points within mainstream IR. Interestingly, Waltz's seminal picture of the world was not always as stable and widely accepted as it appears today. On the very last pages of his classical treatment, he struggled to defend the plausibility of the three images *against the agency of technological changes*.[88] In his text, it seems, Waltz (1959, pp. 234ff.) was barely able to keep under control the defiant non-social agencies, which threaten to destabilize his chain of reasoning.

Although *Man, the State, and War* certainly does not stand for the immense diversity of approaches to IR, it constitutes a privileged object for inquiry as it animates both undergraduate introductory curricula and forms the starting point for theoretical discussions. Through a history of ideas about the reasons for war it develops a three-level model of the world—the individual, the state/society, and the system of states. This model became widely accepted and goes unquestioned as central building block of all mainstream theories (Suganami 2009, p. 381ff., Onuf 1995).[89] Besides Neorealism, the list comprises Neoclassical Realism, Constructivism, Regime-theory, the English School, Neoliberalism, and various poststructuralist authors, who are focused on the inside/outside division (e.g. Walker 1993, Sjoberg 2008). All these approaches explicitly or implicitly presume two things that are set out in Waltz' classic: the primacy of social interaction and the analytical significance of the three levels. Despite repeated efforts to deconstruct *Man, the State, and War*,[90] the structure of its argument remains exemplary and persistent; the study is still plausible to admirers and critics alike, especially for the acclaimed parsimony of its argumentation.

Chapter 4 has examined how Waltz's logocentric ontology derived from Rousseau's stag-hunt allegory. The purpose of this allegory needs to be unpacked further. Though Waltz admits that this story constitutes a "hypothetical reconstruction" (Waltz 1959, p. 167, see also footnote 18 on the same page) of a historical event, he relies on the stag-hunt allegory to make sense of international relations throughout his book. Later, he refers to this allegory to lend credibility to the unitary actor model, that is the

[88] This distinguishes Waltz from Bull and others, who externalize technologies to an extent that the latter do not even appear to threaten theoretical considerations in the first place.
[89] Singer (1961) in another seminal text put forward similar ideas about the relevance of levels.
[90] See e.g. Ashley 1988 and the special edition of *International Relations* (2009: Vol. 23, no. 3).

insignificance of the inherent quality of a state in particular and cultural diversity in general for the cooperation under anarchical conditions (Waltz 1959, p. 183). Anarchy as logic crucial to explanations of inter-state war, thus, relies on a simplistic speculation about the state of nature. It is through this rhetorical means, as Beate Jahn points out, that Realists "get from cultural diversity to uniform power politics" (2000, p. 17).[91] Most importantly, the stag hunt allegory, in Waltz reading, reduces relevant phenomena to the rational and *unmediated* interaction between individuals or states respectively (Waltz 1959, p. 169). Tools, weapons, instruments, technologies, and other kinds of artificial mediators are not present or without relevance, putting Waltz not just in contradiction with ethnographical knowledge.[92] In brief, the stag hunt allegory is constitutive of an implausible definition of anarchy because its "massless" assumptions lead to the illusion of purely "social" relations.

One should not too quickly dismiss Waltz's enormous accomplishment of purification and abstraction (see Sylvester 2001). A cautious note is warranted. After all, he constructed a 'non-material' theory completely at odds with two crucial aspects of the intellectual landscape of his contemporaries: technological determinism and the diversity of autonomous political actors in global politics. Let's start with the second. To begin with, today's state-centric orthodoxy was not in place at the time of Waltz's writing. Waltz effectively replaces a complex and interdisciplinary landscape that flourished among early "IR" thinkers before and after World War II (Ashworth 2013; Williams 2009, p. 330ff.).[93] Despite the Wilsonian vision of a league of equal nations, among the

[91] This is highly insensible to the colonial undercurrents and, thus, the ideological and imperialist purpose of the concept "state of nature" (Jahn 1999, 2000).

[92] Waltz move to use a kind of "genesis" (see Foucault 2005, p. 78ff) is highly problematic. If Waltz had relied on historical and ethnological accounts of possible "states of nature" his depiction certainly would have rejected Rousseau's thought model (Sahlins 2004). Even in Rousseau's own time the knowledge about people in the state of nature was incompatible with such simplistic accounts as for instance Michel de Montainge's essay on "cannibals" illustrates. But the main responsibility here is not on Rousseau's side. Waltz does not offer a justification to why he grants philosophical speculation such a central place in the argument that establishes IR.

[93] The different strands of post-war realist thinking addressed various philosophical, economic, historical, and ethic concerns at the nexus of modern personality, technological progress, and liberal democratic world order. It was by no means restricted to "international politics". I have here for the purpose of this thesis only picked out debates related to technological innovations, especially advancements in weapon technology. For a broader overview that corrects the flawed hagiography of early IR see Williams (2005), Schmidt (2002), and Lebow (2003).

eminent actors in world politics were colonial empires, dynastic sovereigns, and great powers next to many suzerain or dependent polities (Kratochwil 1986, Spruyt 2000, Teschke 2002). Moreover, influential theorists of the first half of the twentieth century such as Oswald Spengler, Arnold J. Toynbee, Carl Schmitt, Ellsworth Huntington, Samuel N. Eisenstadt and Harold Innis employed larger units of analysis such as empires, civilizations, regions, or cultures (see Huntington 1997, p. 325). Meanwhile, the fathers of Realism such as Carr and Morgenthau did not necessarily talk about "nation states" per se, but about a group of great powers—a focus that is still familiar to current realist approaches (cf. Gilpin 1981, Mastanduno 2002). In short, Waltz's book can be read as unlikely success against a dense historical context: back then, "states" were neither the predominant unit of analysis, nor was their treatment as like-units univocally accepted. Critics attacking Waltz because of his model's parsimony and simplicity tend to under-appreciate his actual achievement.

Technological determinism was the other intellectual environment to destabilize; a powerful thought tradition and, as it were, experience which Waltz had to disproof. The majority of his peers considered nuclear weapons in particular—that is, material forces—to impact international relations greatly (Holsti 1985b, pp. 685ff., Deudney 2000b). Thomas Schelling, among many others, emphasized the destabilizing force of technological breakthroughs for deterrence and world peace (Ayson 2004, p. 68ff). Already several decades earlier, pragmatist or functionalist writers such as John Dewey and David Mitrany focused on global interdependence and the consequences of new media and communication technologies (Mitrany 1933, see Cochran 2009).[94] These intellectual traditions that focused on technological change and its discontents are less known due to the biased standard historiography of IR that wrongly foregrounds the realist/idealist divide (Schmidt 2002). But they have figured dominantly as crosscutting themes after the turn of the century:

> "the most extensive body of late nineteenth- and early twentieth-century international theory was the highly materialistic geopolitics of such figures as Friedrich Ratzel, John

[94] Similarly, Edward H. Carr argues in *Conditions of Peace* against the principle of self-determination because of the difficulties to reconcile formally equal units of nation states with military discrepancies and economic dependencies that eventually require larger organizational units (Carr 1942, pp. 50-66).

> Seeley, Alfred Thayer Mahan, Halford Mackinder, H.G. Wells, Karl Haushofer, and many others." (Deudney 2000b, p. 17)

Waltz was writing against this "materialist-determinist" mainstream while looking for other explanations of the outbreak of violence. If technological innovations in weaponry were indeed such a relevant factor, a purely social theory of collective action collapses, as it does not account for continuous technological advancements. Therefore, against a widespread conviction at his time, Waltz had to prove that technological advances actually do not change the basic conditions of IR. He pushed his conceptual efforts to the extreme, denying that there is a meaningful difference between the spear and the hydrogen weapons (Waltz 1959, p. 235). Accordingly, differences between ancient and modern weapons, as it were, have to be assumed irrelevant for explanations of warfare.

> "Advancing technology makes war more horrible and presumably increases the desire for peace; the very rapidity of the advance makes for uncertainty in everyone's military planning and destroys the possibility of an accurate estimate of the likely opposing forces. (…) Each major advance in the technology of war has found its prophet ready to proclaim that war is no longer possible. (…) There may well have been a prophet to proclaim the end of tribal warfare when the spear was invented and another the make a similar prediction when poison was first added to its tip. Unfortunately, these prophets have all been false. The development of atomic and hydrogen weapons may nurture the peace wish of some, the war sentiment of others. (…) The fear of modern weapons, of the danger of destroying the civilizations on the world, is not sufficient to establish the conditions of peace identified in our discussion of the three images of international relations." (Waltz 1959, pp. 235-6)

Waltz recognized that the autonomous force of technological innovations threatens the core of his theoretical framework—otherwise why mention them at the end of his book at all. Nevertheless, he strictly adhered to an instrumental view on technologies.

5.3 Non-temporality, the three-levels, and the return of technology

Waltz had to purify all "things" that could derail his social model. Following the entire chain of argument to which social contract theory has given rise—namely a human world structured around the individual, the societal, and the inter-societal levels respectively—

his argumentation is from an empirical perspective completely untenable; this is true for the eighteenth century as much as it is in our century. As a consequence, Suganami argues convincingly, technology among other factors cannot be located within the three-level schema predominant in today's IR.

> "Think of history, geography, economy and technology, which clearly affect the behaviour of states. Where, within the tripartite scheme, do they belong? To say, for example, that history – historical memories and knowledge claims – belong to 'man', that geographic and economic conditions pertain to 'states', and that the level of technology is a 'systemic' feature, while not entirely implausible, is not going to help us evaluate the relative significance of the three locations of causes, for now so many incongruous items have been placed together under each rubric. The tripartite scheme is no more than one, though standard, way of characterising our political experiences. It is neither necessary nor sensible to squeeze every causal factor of war into the three places." (Suganami 2009, p. 283)

The Waltzian framework, however, has not just difficulties to grant technologies an appropriate place. It has to claim technological innovations (Waltz only refers to arms) to be ultimately irrelevant in the first place. The key to understand this move can be found by comparing *Man, the State, and War* with Martin Wight's famous piece "Why Is There No International Theory?" Wight stresses that the character of international relations is "recurrence and repetition" (1960, p.43). The similarity to Waltz' arguments is remarkable and the attempt to define the "international" is likewise apparent:

> "One wonders whether the prevalent belief that nuclear weapons have transformed international politics, giving the Great Powers something to fear more than they fear one another, and so making war impossible, may not have a similar root. It is clear, at least, that it is the latest in a series of optimistic constructions going back more than a hundred years. In the nineteenth century, public opinion was given the first place as transformer of international politics; in the twentieth century it has usually been the fear of war. The argument that the hydrogen bomb has made war impossible usually contains two propositions: first, that war waged with the new weapons will destroy civilisation; secondly, that it is therefore too horrible to happen. This argument is the core popular pacifism, and was used before each of the world wars. Joad used it in *Why War?* (1939) in respect of the bombing aeroplane. Ivan Bloch used it in *Modern Weapons and Modern War*

> (1900), in respect to mass armies, quick-firing artillery, small-bore rifles, and smokeless powder." (Wight 1960, p. 45)

Cynthia Weber has persuasively argued that Martin Wight's argument (that parallels Waltz')[95] establishes the international as specific site through imposing a tempo-spatial order. At the inside of states or societies there is progress and teleological history; at the outside there is a cyclical history of the repetitive struggle for survival or hegemony under conditions of anarchy. Political theory, hence, speaks to a "history of progress" within the domestic arena while the "cycle" of recurrent pattern belongs to the realm of international relations (Weber 1998, see also Hutchings 2008, Buzan and Little 2009).

We can broaden Weber's examination by focusing on the aspects that threaten this kind of spatial-temporal order. Wight and Waltz, while downplaying the significance of technological advances, both agreed on the timeless quality of international relations, that is, the "recurrent theorem" (Linklater 2009). This view on "History" contradicts other realists who proposed a quite different reading. In the eyes of many of their contemporaries, technological innovations were at odds with the cyclical temporality of the international domain. Most notably in this respect is John Herz who argued that technological innovations were central to understand IR (1951, 1959). Against Waltz and Wight, his *International Politics in the Atomic Age*—which was published in the same year as *State, Man and War*—put forward to forceful argument that the security dilemma had reached "utmost poignancy" (Herz 1959, p. 241). The danger of nuclear annihilation both necessitates and enforces the advent of a universal form of global politics that inevitably transcends the territoriality inherent to three levels that are, following Waltz, the perennial structure of global politics. Because "security concerns were immeasurably increased by the invention of a means of potential annihilation" (Herz 2003b, p. 413), Herz believed that nuclear weapons had put a definitive end to the cycle of rising and declining hegemonies and, consequently, also buried the respective reasoning on balance of power politics (Herz 1959). In other words, according to many proponents of "nuclear realism" technological innovations were capable of creating real historical change to the extent that they displaced a previously repetitive form of time (see Van Munster and

[95] The same argument is forcefully renewed in Holsti (1985b, 2004).

Sylvest 2016).

Against this backdrop, only the exclusion of technological innovation as a matter of concern secured Waltz's main narrative that purports nothing has basically changed since Thucydides. Only domestically, countries and societies could achieve progress (see Weber 1998, pp. 464ff). The "recurrent theorem" contradicts, as point out by Hom and Steele (2010), the complex thinking about temporality and human action advanced by other realist thinkers. It also leads to paradox results if we infer some propositions from it. Accordingly, one would have to claim that technological changes have not significantly altered, for example, warfare, sovereignty, security policies, anarchy, and the balance-of-power politics—all of which clearly contradicts modern experience and discourses on technological changes documented in Chapter 2. Waltz's view, to put it differently, is only possible if one neglects the empirical evidence from the formation of modern states onwards that was intractably related to technological innovations as for instance Morgenthau fully recognized (Lebow 1994, pp. 252ff). Morgenthau explicitly emphasizes the existential difference that modern bureaucratized science and technology innovations make not only for the calculation of power, but also for foreign policy making and democratic control of politics in general (1964).[96]

In sum, Waltz succeeds in stabilizing "three images" and the problem of anarchy as the perennial and specific problem of IR only through disentangling his account of international politics form the grip of technological (and all material) agencies, which were seen as irresistible and pervasive by many of his realist contemporaries.[97] While he followed a crystal-clear mind-matter distinction his logocentric reduction eschewed material factors. Rational minds and the interplay of collective calculations explain the course of politics and the occurrence of war as its most important manifestation; matter was passive, inactive, and instrumental to human purposes.

So, even by risking oversimplification, it can be concluded that Waltz's 1959 book epitomizes a discipline that has eliminated the uncontrollable reality of technological innovations from the core of its epistemological and ontological premises. If the Waltzian

[96] For a detailed examination of different early realist understandings of „time“ see Hom and Steele (2010).

[97] The IR community in general has relegated technological "wild-cards" in the subfield of deterrence studies (see Powell 1985).

framework is representative for IR, then, the exclusion of technological progress *must* lie at the heart of the IR framework itself. IR theories are built upon assuming lightness by their very design. Adding technological factors to existing frameworks therefore faces considerable difficulties, as we have found in the second chapter. In general, this leads to an odd situation: when most IR scholars speak about technologies, it is against the background of an utterly logocentric approach to world politics. This is explains why technology appears as a *deus ex machina*. Waltz's *Theory of International Politics* is an example. It introduces a micro-economic method to measure the capacities of units (including technological capacities) as self-contained variables that feed into the rational calculations among states envisioned by defensive realism. While *State, Man and War* totally silenced technological innovations, Waltz' theory of international politics reintroduces them as purely *statistical* and *instrumental* features of the international structure.

Empirically, this position is untenable. The best illustration being the fact that Waltz has inverted his own position over the years:

> "The long peace would endure because the superpowers possessed nuclear weapons. Waltz was arguing that nuclear weapons, by his definition a unit-level capability can explain war-proneness, the most important system-level property. Such a reductionist argument vitiates the need for a theory of international relations whose principal purpose is to explain war-proneness. This may be why Waltz has subsequently backed away from his characterization of the international system as moving from bipolar to multipolar." (Lebow 1994, p. 254)

Whereas in *Man, the State, and War* nuclear weapons were insignificant for the occurrence of war, its author later acknowledges that "the longest peace yet known has rested on two pillars: bipolarity and nuclear weapons" (cited from Lebow 1994, p. 254).[98] The technological progress that was excluded from *Man, the State, and War* came to haunt Waltz's theory of international politics.

[98] The development of weapons technology even led to the formation of a competitor of the "democratic peace thesis", namely, the "nuclear peace thesis" (see Rauchhaus 2009).

5.4 Plausibility and bricolage

Finally, it needs to be emphasized that *Man, the State, and War* enrolled other powerful devices into its "bricolage". Particularly, computer modeling and game theory are employed by Waltz to shed light on the issue of balance of power. He refers first and foremost to John von Neumann as the compelling source of his age. The argument goes as follows: the important "clue" about the logic of balance of power, "a logic that is intimately connected with the third image of international relations" stems from computer models. In addition, Waltz also cites another influential source related to computer modeling.[99] Morton A. Kaplan's *System and Process in International Politics* (Waltz 1959, pp. 200-1) was the first major account to *model* international relations as system. Indeed, Hedley Bull stresses that Kaplan popularized the term "international system" through his works (Bull 1977, p. 12).

System analysis requires strict definitions of the involved units. Their character and behavior need to be clearly delimitated through typologies and are interdependent upon each other (Kaplan 1957, pp. 54ff., Kaplan 1966, pp. 469-471). This ties harmoniously into Waltz's own arguments. It made the collection of mainly historic ideas more plausible through endowing it with the scientific prestige of computer simulations that, meanwhile became crucial for the closure of the deterrence debate (see Adler 1992). Waltz's art of assembling shows no hesitation to connect Rousseau's contract philosophy with descriptions of Bismarck's policies and von Neumann's game theory.

> "If this seems complicated to the point of frustration to some, to others it is what makes international politics a fascinating 'game'. That it is a game, with no frivolity intended, will be clear if the comments just made are compared with those based on the equally frustrating and fascinating mathematical speculations of von Neumann and Morgenstern. The third image in general and balance-of-power analysis in particular are relevant in the present as they have been in the past histories of multi-state systems" (Waltz 1959, p. 223).

Perhaps the three levels became so convincing and effective because they resemble boundary objects. They have enabled Waltz to connect social contract theories of the eighteenth century with a genesis story that narrates the beginning of human societies,

[99] Other scholars such as Karl Deutsch draw much more systematically on system sciences and cybernetics to understand and theorize government (Deutsch 1969, see Pfaltzgraff 1972).

computer modeling and game theory with the diplomatic history from Thucydides to Churchill, the state of nature concept conflated with "anarchy" with morality and system theory. It is this blending of things, concepts, methods, persons, and stories, which deem *Man, the State, and War* both a powerful argumentation and a stable theoretical conceptualization. For Waltz and many of his readers this bricolage is persuasive both as description and prescription. Waltz even appears to regard simulations as more real than history: after discussing the bearing of game theory on international relations across five pages he concludes by stating, "the preceding analysis indicates that the balance of power among states has a firm basis in *reality*, that it is much more than a 'delusion'" (Waltz 1959, p. 207; italics by author).

Of course, *Man, the State, and War* certainly cannot be seen as sole mainspring of the Cartesian complex within IR. But the book fully encapsulates its basic tenets and onto-political commitments. *Man, the State, and War* became instrumental in the making of the three images, the privileged position of unit-like states, and the state-system through assembling a lot of heterogeneous things. Waltz's three images are not only admirable for ending the non-discrimination between suzerain states, great powers, empires, dominions, and other possible contenders of agency in "international relations".[100] Against the epistemological and ontological mingle of his times, he amalgamated an answer, unmatched in its clarity, to one of the most fatal questions: inter-state war.

Yet, this was achieved at considerable costs. Structural realism advocated a tempo-spatial model of the world that purports a double temporality (inside teleological progress toward the pursuit of happiness and outside the perennial cycle of war) at the expense of technological innovations. Waltz succeeded by setting out a way of externalizing the material actors that have haunted politicians and experts throughout the 1950s and 1960s. This conceptual move has been very effective until lately, as legions of students of IR are still socialized with a black-boxed version of Waltz's approach. Especially, the three-level schema has become an obligatory passage point. Most post-structural approaches only have reified this "lightness" by clustering their critiques around a basically logo-

[100] It goes without saying that exactly this move to exclude other actors on the world stage was always a central critique against Waltz's theory. However, here the unitary treatment of "states" is most important.

centric scheme (see Mitchel 2002, p. 2ff). In turn, it is intriguing to follow the practices and materials contained in Waltz's text. Arguably, the entanglement of computer models and contract theories seems to render his notions compelling and enduring.

5.5 Summary

Digging into the deep strata of a classical work of IR is informative. It helps to understand the challenges of resetting the current onto-politics of IR. So, let us briefly summarize the main reasons that buttress the need for a post-Cartesian framework. Firstly, the inquiry in the historical politics of technological innovations carried out in Chapter 3 clearly indicates the limitations of the meta-theoretical framework of IR. Especially, IR theories fell short of advancing models of dynamic technological changes that come close to the sophistication that Marx, Innis or Schumpeter had already achieved.[101] Secondly, because the meager IR literature on technological innovations constantly bumps against conceptual boundaries, the framework of IR needs to be radically reconsidered. Thirdly, this can be realized by novel approaches to ontology and methodology. IR scholars, often at the disciplinary margins, have shown that an ontological opening produces stunning insights. Many scholars who have done research about technologies and international relations point to the need for interdisciplinary cross-fertilization. Meanwhile, various neighboring disciplines have indeed ventured fairly well in developing a conceptual language that is applicable to technological changes. If it is true that IR is lagging behind we should not ritually silence this knowledge and instead mine these resources for concepts and theoretical inspiration.

Ultimately, to pursue ontological expansion—by proliferating new foundational collectors—implies that we reconstruct basic parameters of the discipline. Since the blind spot concerning technological innovations is intimately connected to notions constitutive to IR, an alternative framework should serve the task of shedding light on both the question of how we can make sense of technological innovations and on the actual restrictions of the ontological parameters underpinning IR theories. In this sense, the subsequent chapters draw on different extra-disciplinary sources to lay out an explorative

[101] For a critical overview on models of change in IR see Holsti (1998b).

realist approach. The approach of explorative realism (developed in Chapter 6 and 7) involves ontological expansion to address the role of material agency (Schouten and Mayer 2017).

6. Explorative realism: theory and knowledge

The preceding chapters give the impression that the objects of our theoretical inquiry are considerably difficult to grasp. The politics of technological innovations imply a "drama" that causes a serious insecurity on the part of the observer who aims at capturing their ontological properties and evolution. Seeing especially how theorists such as Karl Marx, Joseph Schumpeter, and Harold Innis have struggled to make sense of the transformative properties of technological innovations, we conclude that both a determinist and a social reductionist analysis turn the concern with technology into a conceptual minefield. Pointing to the critical issues of agency, process, and the proper units of analysis, I have reasoned that the conceptual shortcomings of existing approaches in IR stem from their problematic presuppositions at the ontological level. Specifically, the premise of a material-social divide diminishes the ability to compose adequate descriptions of technological innovations (Chapter 2 and 3). As the usual socio-technical divide collapses, an appropriate conceptual language is lacking to account for the dynamics of co-productive processes.

It is worthwhile to reflect on historical experiences in order to gain a better understanding of this predicament. The theoretical fuzziness resembles the fundamental problem that Denis Diderot encountered when he began to work on the *Encyclopedia* which would become a 28-volume work. In 1747, Diderot and Jean le Rond d'Alembert were among the first European philosophers to see emerging new technologies and related knowledge as a serious societal issue. To narrate the mix of tacit knowledge, machine tools, scientific assumptions and technically organized production required a rather different approach to collect data and depict objects (Proust 1984, p. 4, Sennet 2008, pp. 94ff). They were convinced that combining thousands of images and texts was the best way to convey the power and authority of science to eighteenth century European publics (see Feenberg 1999, Ezrahi 1990, p. 82). But they soon observed a mismatch between language and reality that was very difficult to overcome. The words, concepts, and metaphors that Diderot used for annotating the numerous illustrations of the *Encyclopedia* could not clearly express what was visible. Neither "the worker nor the analyst of labor can really explain what's happening." (Sennet 2008, p. 106) Diderot let pass the impulse to reinstall order by imposing another, potentially more suitable, systematic conceptual grid. When it comes to clarify the operations of technological innovations, the extraordinary acknowledged of the limitations of vocabulary offers clues for thinking about the roadblocks met by IR theorizing.

To make sense of the incomprehensibility of technological innovations requires a novel approach. Chapter 4 and 5 sketch out the core elements of such a meta-theoretical framework and the corresponding research design: *explorative realism*. In order to do so, we first need to clarify some foundations. One important source of relevant insights for this task is the philosophy of science. Though the philosophy of science is a vessel that contains many different views, it is agreed upon presuming that scientific practice inadvertently involves ontological and epistemological commitments. Conversely, the social sciences, including IR, are practically always intertwined with philosophy if often unrecognized (Kuhn 1970, Bunge 1996, Bashkar 1989). Most IR scholars agree that meta-theoretical considerations and commitments need to be clarified from the outset. But the discipline is divided along several fissures regarding the three main components of meta-theory: ontological presuppositions, theoretical assumptions and methods, and the epistemological underpinnings of scientific truth (see Wight 2002). Consider the so-called “third debate” that animated the discipline. It has challenged the predominant positivist and rationalist scholarship on the conceptual level. But it has also placed the foundational commitments within the discipline under sustained scrutiny (Cox 1981, Lapid 1989).[102] Ever since, the conversation about the philosophical underpinnings of IR has been ongoing (Hollis and Smith 1990, Wendt 1992, George 1994).

The most recent debate about philosophical foundations reveals that the characteristics, the viability, and the legitimacy of diverging *foundational commitments* are highly contested among IR scholars.[103] Competing meta-theoretical frameworks have been proposed based on preferences grounded, for instance, in critical realism, pragmatism, or social constructivism. Throughout this chapter, it becomes obvious that

[102] See Almond and Genco (1977) for an earlier call to revisit foundations.

[103] Several forums and symposia have discussed these issues at great length. See Millennium (2007: Vol. 35, no. 2), Review of International Studies (2012: Vol. 38, no. 1), and International Theory (2009: Vol. 1, no. 3).

we must take issue with these competing hegemonic ambitions. Firstly, because there are good reasons to believe that the claims to meta-theoretical monocultures are misplaced. Instead, the existence of multiple perspectives is a healthy state of our discipline—not despite, but because of the often-incommensurable nature of meta-theories. Secondly, while these debates center on epistemological questions—the problem of reliable evidence and sound scientific knowledge about international relations—my considerations lead to a different direction. Aiming at a post-Cartesian theory of knowledge, we need to clarify the "onto-political" entailed in the philosophical foundations of our research design.

This chapter particularly elaborates the kind of meta-theoretical commitments that render feasible *assessments of actuality* (Campbell 1998, p. 504). In other words, it must become clear in what ways specific philosophical a priori are constraining the comprehension of technological innovations on the ontological level. In this sense, explorative realism can be understood as one foundational position among others—though it is not another contender for epistemological hegemony. The distinctive feature of explorative realism, though it is perhaps closest to pragmatism, is not its opposition to epistemological police officers. Rather, at its core lies the strong impulse for *expanding ontological parameters*. It echoes Colin Wight's (2006) argument that becoming realist about the world means coming to terms with perplexing diversity and complexity. Explorative realism requires that we direct our concern towards new objects, processes, agencies, and modes of existence relevant for IR while postponing epistemological quarrels.

Preparing the discussion of the ontological level which unfolds in Chapter 5, the epistemological and methodological elements of explorative realism are sketched out in the following. First, I reconsider the role of theory in the context of a "non-normal" IR. Against the background of the current situation, I argue that theoretical concepts should enable ontological expansion (6.1). This leads one to investigate the functions of theories especially focusing on dissident approaches to international relations. My approach to meta-theory particularly emphasizes the explorative or investigative function. Theory, in conclusion, is defined here as a preliminary map in support of an explorative research practice (6.2). Qualifying pragmatic thinking, knowledge production is conceptualized as the stabilization of truth claims. In line with social constructivism, I point to the "constitutive" character of scientific knowledge. But against social constructivism, I refute social reductionism and the limitation of agency to intentional actors. Remaking realist understandings, the fact-value dichotomy is substituted by a gradient which reaches from matters of concern to matters of fact. This approach, thus, rejects Humean positivism and correspondence models of truth (6.3). Finally, I elaborate how the practice of ontological expansion is related to questions of criticality, ethics, and methodical issues. From explorative realism follow two methodological propositions for approaching the politics of technological innovations: For one, researchers stay in a prolonged state of "limbo" that is however productive. For another, theoretical vocabulary and analytical tools, first of all, should enable us to capture and describe heterogeneous and fluid multiplicities To fit together the bits and parcels of the politics of technological innovation we need "foundational collectors", rather than "foundational positions" (6.4).

6.1 Non-normal science and the limits of IR

To introduce the notion of "explorative realism" as a foundational approach, we first need to tackle more generally the current state of IR in relation to the purpose of theories. Theoretical diversity characterizes the discipline more than ever. The majority of scholars, by now, appears appreciating, or at least adapting to, the growing methodical and theoretical diversification (Sil and Katzenstein 2010).[104] However, their appreciation of this condition has conflicting motives. Friedrichs and Kratochwil (2009), for example, argue that the goal of "useful" knowledge warrants methodical plurality for its own sake. Patomäki and Wight (2000, Wight 2006) value different theoretical perspectives and methodological pluralism as essential means to capture complex realities. Buzan and Little (2001) argue that multiple perspectives would help with overcoming the failure of IR to display relevance beyond its own narrow disciplinary borders. For Monteiro and Ruby (2009a) post-foundationalism is a recipe to cure the discipline from cleavages arising from unproductive disputes about foundational positions, whereas Moravcsik's

[104] The foundations and limits of the discipline of international relations are essentially contested. Theoretical pluralism is a fact, yet it is far from a universally shared normative position among the participants to paraphrase Dunne, Kurki, and Smith's (2010, p. vi) introduction to a recent IR theories reader.

(2003) ultimate aim is to abandon theoretical pluralism through synthesizing theories. Accordingly, theories should be empirically tested. IR should be rendered problem-driven in order to develop sound multi-causal explanations. In opposition to this instrumentalist reading, Cox values pluralism since theoretical monocultures of "problem solving" are prone to ahistorical reasoning. He also reminds us at the onset of the "third debate" that perspective uniformity conceals the politics of purpose inherent to all theories (Cox 1981). This move, however, implies keeping up the status quo as unified views bury the potential for revolutionary agency (Booth 2007a).

But the case for "multi-perspectivism" remains unconvincing. While I sympathize with theoretical and methodical pluralism, not all of its advantages are fully understood yet. A central reason that legitimizes the endorsement of diversity concerns the *functions* of theories in IR. Whereas foundational debates were focus on epistemology, the orthodox functions of theory *vis*-à-*vis* empirical materials went unchallenged. Interestingly, within conflicting foundational positions such as critical realism, social constructivism, and pragmatism, theories may have different content but standard definitions of theory still usually assume "patterns to international events and that IR theory is about revealing those patterns," and subsequently explaining them (Sterling-Folker 2006, p. 4). Theories have the purpose of ordering data and explaining regularities. The odd consensus about what theory should be able to do is illustrated by Samuel P. Huntington's attempt to advocating an alternative view on global politics after the end of the Cold War. He advances that "simplified paradigms or maps are indispensable for human thought and action" (Huntington 1997, p. 30). Huntington proceeds to explain the specific advantages of having maps:

> "Every model or map is an abstraction and will be more useful for some purposes than for others. A road map shows us how to drive from A to B, but will not be very useful if we are piloting a plane, in which case we will want a map highlighting airfields, radio beacons, flight paths, and topography. With no map, however, we will be lost. The more detailed a map is the more fully it will reflect reality. An extremely detailed map, however, will not be useful for many purposes. If we wish to get from one big city to another on a major expressway, we do not need and may find confusing a map, which includes much information unrelated to automotive transportation and in which the major highways are

lost in a complex mass of secondary roads. A map, on the other hand, which had only one expressway on it would eliminate much reality and limit our ability to find alternative routes if the expressway were blocked by a major accident. In short, we need a map that both portrays reality and simplifies reality in a way that best serves our purposes." (Huntington 1997, p. 30-31)

This vivid account is, arguably, a commonplace for most IR scholars. Indeed, the participants of the most recent foundational debate, however divided they remain on other matters, would agree with Huntington's broad understanding (albeit not with his undifferentiated terminology). The purpose of theories, models or maps, to paraphrase Huntington, includes ordering, abstracting and generalizing reality, understanding causal relationships between phenomena, anticipate and predict future developments, distinguishing primary from secondary issues, and evaluating policy choices.[105] And this leads to an intriguing observation. Monteiro's and Ruby's argument about the "false promise of philosophical foundations" (Monteiro and Ruby 2009a, 2009b), which stipulated a lively debate, omits a consideration of specifically how *theories* were affected by their vision of post-foundationalism. Why does the essential contestation of IR's philosophical foundation (foremost its epistemology) not also have significant impact upon the status of theories? The function of theories appears surprisingly self-evident and stable even if anything else crumbles.

In other word, how to render Huntington's reasoning about maps less convincing? To comprehend what is puzzling about the non-controversial status of theory,[106] I believe we need an alternative reading of the contemporary foundational debate, a reading that sheds light on the forgotten "explorative function" of theories, a function which combines mixes „Ontological" and „empirical theorizing" as suggested by Stefano Guzzini (2013). This function is a central premise of explorative realism and critical for the progress of a post-foundational IR for reasons that will become clear within a moment. Adopting a broader historical-comparative view upon the development of IR helps to contextualize

[105] For maps as research tool see Schouten, Loughlan, Olsson, and Anderson (2013).

[106] Note that this point is not identical with questions such as the general function of theories for research practice, scientific explanations or critique.

IR's current multi-perspectivity and reveals why "theory" ought to be different treated. [107]

Philosophers of science supply two possible readings of the contemporary predicament of theories: Following Kuhn, IR could be understood as a discipline in its infancy or in crisis. "The early developmental stages of most sciences have been characterized by continual competition between a number of distinct views of nature, each partially derived from, and all roughly compatible with, the dictates of scientific observation and method. What differentiated these various schools was not one or another failure of method—they were all 'scientific'—but what we shall come to call their incommensurable ways of seeing the world and of practicing science in it." (Kuhn 1970, p. 4) Accordingly, it will require some time for IR to outgrow a non-mature stage and reach an equilibrium level, squeezing perspectivism by introducing a real paradigm.[108]

Alternatively, we could follow Funtowicz's and Ravetz's (1993) considerations. According to their reframing of Kuhn's concept, IR could have arrived in a phase of "post-normal science" by now. Thus, "the reductionist, analytical worldview which divides systems into ever smaller elements, studied by ever more esoteric specialism, is being replaced by a systematic, synthetic and humanistic approach. The old dichotomies of facts and values are being transcended. Natural systems are recognized as dynamic and complex; those involving interactions with humanity are 'emergent', including properties of reflection and contradiction. The science appropriate to this new condition will be based on the assumptions of unpredictability, incomplete control and a plurality of legitimate perspectives." (Funtowicz and Ravetz 1993, p. 739)

Both narratives, in spite of their conflicting recipes, carry a common theme. Theoretical perspectivism emerges as response to shifts and twists *at the ontological level*. In short, reality is uncontrollable and ontology is not fixed. Under this condition, puzzle-solving practice is impossible. For it depends on "the ability (…) to group objects

[107] To trace the institutional and personal roots of its intellectual currents and methodical fancies from the sociology of science's angle (Hoffmann 1977, Weaver 1996, 1998, Smith 2000, Bueger 2012) is not sufficient for our purpose. It does not provide answers to the question as to what the current function of theories could be because it remains fixed on internal issues and trends.

[108] Wight (2002, p. 31) wonders how Kuhn's concept of paradigms could get so much (mis)used in IR, while Kuhn doubted that social sciences would ever become "mature".

and situations into similarity sets which are primitive in the sense that the grouping is done without an answer to the question, 'Similar with respect to what?'" In other words, an unfolding scientific crisis melts down all sorts of ontological and epistemological orthodoxies (Kuhn 1970, p. 200). So, when scholars appeal to a seemingly ambiguous "reality" they increase the difficulties of communicating incommensurable scientific views. For Kuhn, this confusing experience indicates the practice of non-normal science. This is suggestive for IR's current constitution—whether we deem it to live through a crisis or the stage of early childhood (cf. Frieden and Lake 2005). Scrutinizing foundations, as it currently occurs, seems primarily a response to the ontological level although it is pursued in the epistemological arena.

It must be understood at this point that theories do not offer conflicting explanations for similar puzzles. They are instead ontological doors to radically different worlds. If this description applies to IR, we should generally welcome foundational exchanges and advances because they prelude major theoretical innovations, as Kuhn points out (1970, p. 85). The crucial insight from the philosophical perspective on non-normal science is, then, that theories are mainly instruments for exploring the "unknown unknowns" of the cosmos. Meanwhile, we recognize by now that the explorative function of theories is completely absent from Huntington's narrative. The landscape, the roads and expressways that he wants to navigate appear unproblematic because they are generally known in advance. His concerns with the use of the map are centered on the correct zoom and the selection from a large pool of established matters of facts. Nothing new to discover here; the sole purpose is proper navigation. Similarly, theories do not feature as *tools for discovering* new worlds in the post-foundational debate.

This lack of concern for novelty is evident from Robert Cox's influential typology. Cox based his two types of theory on the argument that theories are "always for someone and for some purpose" (Cox 1981, p. 128), putting himself the premium on critical inquiry. Originally, his critical-Marxist approach primarily was focused on actively bringing about changes in world order for good (Cox 1981, pp. 149-151). But as he points out more recently, his actual contribution to IR was "to broaden the idea of 'the international' beyond the realm of political/military interactions of states". In this line, Cox sees his approach as front-runner in "a departure from what might be called a

Cartesian view of politics." (Cox 2007, p. 514) Regardless the viability of this assessment, in retrospect, Cox's true innovation was less the "critical" function of theory. His genuine contribution to IR came in the form of a massive expansion of the discipline's ontological limits. And yet, this claim reveals a blind spot within Cox's own typology. It does not conceptualize the property of theories, among other things, to possess an irreducible explorative power. The recourse to other scientific disciplines only reinforces our curiosity here. For example, the physicists' playful appreciation of models for exploring novel matters in the universe, quantum matter, or planetary movements and so on (Randall 2006, pp. 87-97), indicates the almost pathological state of IR: the disciplined meta-theoretical imaginary is merely about "policy advice", "regular patterns", "causal explanations" or "emancipatory critique".[109]

This leads us to a difficult question: why is the critical property of theories to enable explorations not fully acknowledged or rather neglected during meta-theoretical debates? The lack of historiographical depth that marks the current debate about foundations surely is one reason. Despite multiple earlier integrations of Kuhn's ideas (see Wight 2002, pp. 31ff), the scholarly community is not taking into consideration the discipline's scientific trajectory and maturity through Kuhnian lenses. The critical function of theories, hence, remains uncontested. But this is only half of the explanation. Cynthia Weber offers a complementary reading of the seemingly a-historical nature of intra-disciplinary deliberations. Weber's analysis treats theories as cultural myths that are perpetuated through storytelling. At a higher level, storytelling is effectively veiling the mythic character of the basic framework of IR itself. That is the framework that functions as master narrative for all other stories and silently reproduced by them. Writes Weber:

> "As a site of cultural practices, IR theory provides not just the stories about international politics but the framework which makes these stories meaningful, serious, and important. And it is this grid, this support, this basis for storytelling that goes without saying in IR theory itself – that it is reasonable, rational, and objective to narrate stories about IR theory which focus almost exclusively on sovereign nation-states in anarchy and the "high

[109] Contrarily, as the multifaceted application and function of "models" in physics affirms it could be tied into a joyful practice of trying out, making sense of data and developing theories and so on. It should be noted that the meaning and function of a model, as well as its relation to reality, data, and theories is contested in physics. See Hartmann (1994) and Etkina, Warren, and Gentile (2006).

> political" practices their interactions give rise to. (…) IR theory itself underwent (and is always really undergoing) a mythologizing function so that its framework for analysis appears to be natural, neutral and common sense rather than cultural, ideological, and in need of critical analysis. While exposing the myth function in IR theory would not put an end to it (for we never escape culture and ideology), it may temporarily disrupt it. And if IR theory's myth function is disrupted, then this might open up new possibilities for uncharted stories about international politics to be told. This would be a terrible threat to traditional IR theory." (Weber 2005, p. 184)

Weber's story reminds one of the naiveté of putting forth the question whether there might exist anything radically novel to discover. The question is whether there is anything unexpected beyond the discipline's horizon, which is *real and relevant* for our profession and therefore could undermine the fixed delimitations of our ontological framework.[110] These irritated questions, irritated by the complacent self-confidence one finds in papers, research projects, and books as well as during conferences and discussions with colleagues, strongly resonate with Buzan's and Little's critique that the "intellectual project" of IR has failed. They regard IR's standard ontological parameters as "hopelessly narrow and oversimplified" (Buzan and Little 2001, p. 30). The levels of analysis, the units and logics of interactions, the potential puzzles and problem-fields: not much has been diversified in decades

Buzan and Little further lament that the narrow domain of IR theories is treated as a settled issue, for "the IR community has been seduced into wearing the Westphalian straitjacket." (Buzan and Little 2001, p. 26) Their contention is strikingly similar to an earlier indictment by Susan Strange. She states that "even at their most extensive, the 'directional' or 'azimuthal' agendas that exist are still far too restrictive and so do not really qualify as the study of political economy." (Strange 1988, p. 13) In the same vein, Chris Brown maintains that none of the concepts making sense of post-Cold War world have had their origins within IR theories. Notwithstanding the need for theoretical rigor, he states that "there is a world of difference between disciplined thought *about* international relations and the notion of a discipline *of* International Relations. One can have the first without the second—and having the second does not guarantee the first."

[110] Besides, of course, the fictitious threat of zombies (Drezner 2011).

(Brown 2007, p. 249) I propose to address this predicament through developing further the explorative function of theories.

6.2 The explorative function of theory

In general, the claim that mainstream IR is hardly, if at all, interested in "new possibilities for uncharted stories about international politics" (Weber 2005, p. 184) is correct. Though, a few cautious notes are warranted. Particularly, scholars at the margins of the discipline defy this description. These scholars, many of whom advance contested epistemological and ontological parameters, were both explorative and incompatible with the positivist mainstream research programs (cf. Zalewski 1993, Smith, Booth, and Zalewski 1996, Youngs 2004). Undoubtedly, mainstream IR has not paid enough attention to personalities whose research practice comes close to the working style of Charles Darwin or Alexander von Humboldt. Robert Keohane's attempts to discipline feminist approaches to IR under the authoritative umbrella of a pre-fixed research program is exemplary for this tendency (Weber 1994, Tickner 1998). The incomplete comprehension of the function of theories is, in this sense, merely the reflection of a scientific practice that reifies variables and abstract concepts at the expense of describing the actual practices of international relations.

Re-reading the writings of genuine "explorers" borne into our discipline, in turn, offers both a telling story about the dismal status of IR and clues about the explorative function of theories. The research conducted by Cynthia Enloe and Susan Strange can be singled out for this purpose. How does their work help us reshaping our understanding of theories? Both have, albeit in different ways, written impressively dense descriptions of the reality of international politics. These accounts are stunning to the reader first and foremost because they relentlessly transcend the traditional ontological scope accepted within the IR community (Enloe 2000, Strange 1988). For example, in the vast uncharted landscape that Strange sets out to explore the international system appears but as one, almost marginalized, complex. A complex of interactions that is, according to Strange, surrounded and crisscrossed by myriads of non-state actors, economic agencies and social struggles, and, in addition, complex historical legacies, value conflicts, and technical innovations merging at the "market-authority nexus" (Strange 1988, p. 22).

In a similar sense, yet from an early feminist perspective, Enloe argues that "we risk being globally naive" (Enloe 2000, p. xiv) if we do not investigate the entirety of the international system. It would be silly leaving "untouched our presumptions about just what 'international politics' is." (ibid. 2000, p. 196) Writes Enloe:

> "Governments need more than secrecy and intelligence agencies; they need wives who are willing to provide their diplomatic husbands with unpaid services so those men can develop trusting relationships with other diplomatic husbands. They need not only military hardware, but a steady supply of women's sexual services to convince their soldiers that they are manly. To operate in the international arena governments seek other governments' recognition of their sovereignty; but they also depend on ideas about masculinized dignity and feminized sacrifice to sustain that sense of autonomous nationhood. (…) An exploration of agribusiness, prostitution, foreign-service sexism and attempts to tame outspoken nationalist women with homophobic taunts all reveal that in reality it takes much more power to construct and perpetuate international political relations than we have been led to believe." (Enloe 2000, pp. 196-197)

Strange's and Enloe's outstanding investigations provide crucial lessons that are often overlooked during the debate about philosophical foundations. First, while they aspired to grasp and describe international relations in their entire scope and dimensionality, they have largely stayed aloof epistemological skirmishes. Furthermore, Enloe and Strange have employed an almost invisible theoretical toolbox and a sort of infra-language to facilitate curiosity and discovery (Enloe 2004). In this sense, methods, theoretical concepts and frameworks are not seen as an end in itself that warrant rigorous epistemological safeguards as a precondition for research. Rather, theoretical apparatuses make sense only if they foster *curiosity* about the things one does not know yet, and enable a non-reductionist, *realistic investigation* into the multiplicity of the world (Enloe 2007, Aradau and Huysmans 2013).

Such an investigation reveals, according to Enloe, that sustaining international politics is "far more complicated than most experts would have us believe." Thus, she is not appealing to specific theories or methods, but rather to the nitty-gritty of fieldwork. The foundational claim, which Enloe consequently advances without much ado, is the proposition that “the international is personal” (Enloe 2000, p. 196-197). Her foundational position is not cloaked in epistemological silk. Like other feminist explorers, Enloe prioritizes hidden contexts, personal experiences and biographies, and real local or corporal situations to carve out the role of women in sustaining the “international”. Christine Sylvester, in a similar sense, juxtaposes the abstractness of isolated male-made hypothesis testing and stylized facts with Sandra Harding’s “feminist empiricism” that foregrounds the “context of discovery”, putting the researcher onto the same plane with its subject matter (Sylvester 1994, p.33). The main concern of these dissident voices amounts to “first-order questions about the world”, as Griffiths and Callaghan note, rather than to a-priori limiting the scope of international relations (Griffiths and Callaghan 2000, p. 199).

Enloe’s feminist IR and Strange’s global political economy illustrate that minimal theoretical tools put into practice can be highly innovative with respect to shifting IR’s prior ontological demarcations. This captures precisely the where explorative realism identifies the main function of theories; its underlying problematique is peculiar: it cannot be confused with the epistemological problems of the Kantian object-subject duality (Patomäki and Wight 2000). Nor is it similar to the critical realist concerns for “correspondence” between theory and reality (Wight 2007). The key difference is that theories here unearth ontological novelties. Quoting again from Jennifer Sterling-Folker’s introduction to IR theory helps to clarify what is at stake here:

> “Another useful analogy is to think of IR theory as a set of perspectives equivalent to the alternative lenses one might use on a 35mm camera. The subject may be an elephant in grasslands, but an alternative lens will reveal different aspects and details of the elephant and its surroundings so that, as Barry Buzan says, “looking through it makes some features stand out more strongly while pushing others into the background” (…) The basic lens provides a shot of the elephant and its setting immediately to its front, back, and sides. A panoramic lens suddenly makes the elephant seem smaller in relation to its surroundings, which are now more expansive and more important to the image. A series of close-up lenses draw attention ever nearer to the elephant, enlarging it until its surroundings no longer seem relevant and details that had escaped attention before are noticeable. Tinted lenses of yellow, red, or blue highlight different shadows and features that had not seemed pertinent or particularly noteworthy with other lenses.” (Sterling-Folker 2006, p. 5)

In line with Huntington, Sterling-Folker's metaphorical story perfectly captures one important function of theory—the usage of different lenses for zooming in and out in order to get a complete picture of the subject matter. Conceptualizing theory in terms of its potential for exploration, however, would turn this narrative on its head by asking how theories enable one to discover, in the first place, an elephant in the grasslands, or even the entire species of elephants. In a similar sense, what counts is not the resolution of a map or the set of features that has been selected. Against Huntington, theories, maps, or models have to feature the "white areas" and must lead to places without a stable "order". It should offer clues and hints about where we might feel insecure to the extent that we walk on instable ground. It should point to locations where the dimensions and parameters on which we usually rely might not hold. It is the edges of a map, where the clarity of representation is muddled, that attract our attention.

Putting such a demand to maps seems odd only if we expect maps to deliver exact representations and forget the contingency of map making. If the landscape is unstable, a map that employs the logic of stability—focused on the known—will guide us into perplexing and paradoxical situations. Instead, what our map should do is to support navigating the insecure categories, unclear processes, and unknown agencies. Our travel itinerary could take us to broken expressways between two metropolises, or across nano-particles in the human body or to mountain tribes that lack categories of statehood. Differently, we could plan visiting assembly lines or air force drone facilities where humans converge with machines and are stretched over virtual spaces; or, perhaps, satellite equipped nomads, online-shamans, and stateless migrants. As such, the content of a specific map (and some auxiliary travel guides) were to offer us different axes and dimensions of controversial subject matters.

Explorative realism, in other words, understands theories as working tools that help to uncover real-world multiplicities and complexity under conditions of analytical uncertainty. That one should never mistake the map for the landscape, here, takes on a new meaning. Theory does not refer to a pre-given "order" and, therefore, does not foreclose what we might encounter. In turn, reading theories in accordance with explorative realism explains the marvelous and surprising experience if one turns to Strange's and Enloe's texts.

We are now familiar with the explorative function of theories. What needs to be done is to systematize this function. Table 3.1 shows two related subdivisions: The first is named "foundational collectors". Their role is expanding (or restricting) the uncertainties that we are able to "perceive" at the ontological level. Foundational collectors, thus, enable us on the one hand to disclose uncharted empirical landscapes and on the other hand to multiply objects, sets of objects, and sets of sets of objects. In practice, they can be freely applied to texts, archives, or used in the field. The second column displays "conceptual models", which enable researchers to connect different objects, to circumscribe processes, and to think about puzzles using various concepts. This conceptual language does not aim, ultimately, to contribute to or being assessed by an isolated "Theory". Rather, as suggested, the two types of theoretical tools—employed separately or in combined fashion—are at the disposal of an explorative IR. Accordingly, theories do not resemble "as if" operations typical for instrumentalist frameworks such as Waltz' *Theory of International Politics* (Monteiro and Ruby 2009a, p. 27). Neither are they sets of assumptions about causality or causal explanations of empirical variations (cf. Kurki 2006). Theories understood in this sense neither buttress truth claims, nor critically inquire historical contingencies. Their only purpose is *enabling scientific exploration in practice*. In short, theory, instead of delivering answers to epistemology, poses questions to empirics.

	foundational collectors	**conceptual models**
function	opens up new landscapes multiplying objects and processes	sorts out relevant processes and interconnections parameterization
nature	statement definition slogan motto	data-driven middle-range proposition
metaphor	map network web flashlight lens chart paradigm	framework concept hypothesis model toy-model working-model

example	'international system' 'world system' 'the international is personal' 'global-local' 'coproduction of order'	'state' 'sovereignty' 'markets' 'power' 'associations' 'stabilization'
practical purpose	a tool for discovering and description	a tool for selecting of sets of cases and formatting and comparing puzzles

.... TABLE 6.1 THEORETICAL TOOLS FOR AN EXPLORATIVE REALISM ©AUTHOR

Given that the politics of technological innovations still represent an under-researched subject matter in IR, foundational collectors will play a crucial role for my purpose.[111] Moreover, foundational collectors play an instrumental role concerning the multi-perspectivity of IR. Their innovational capacity could become a decisive factor for the progress of the entire discipline. To realize their potential, foundational collectors must be understood as, to quote Jackson, "working assumptions, or wagers, and evaluated for their analytical productivity rather than in terms of their ultimate philosophical validity" (Jackson 2009, p. 463). But as a mental precondition, we have to revitalize the creative dimension of IR. "At the core of the theorizing process is a creative imagination", reminds James Rosenau students of international politics, and maintains: "to think theoretically one must allow one's mind to run freely, to be playful, to toy around with what might seem absurd, to posit seemingly unrealistic circumstance and speculate what would follow if they were ever to come pass." (Rosenau 1980, p. 35)

Rosenau's plea applies to the *ontological level* in equal terms. The explorative mind-set is imperative for non-normal conditions. While "the commitments that govern normal science" restrict the entities contained in the world according to Kuhn (1970, p. 7), we are by now released from these chains. Why not open our descriptions for additional objects, processes, beasts, relations, modes, and existences--all of which were dwelling beyond the great wall of restrictive onto-politics. The proliferation of foundational collectors could lead to an age of ontological revolutions. It would therefore be mistaken to perceive the contemporary foundational debates as boring burden or as

[111] As the second chapter has shown, technological innovations warrant a special attention at the ontological level, as their fluid character is evading the typical conceptual boundaries that social science draws between the "social" and the "technical" domain (De Laet and Mol 2000, Mol and Law 1994).

dry exercises. Instead, multiplying perspectives, diversifying assumptions, and differentiating methodologies gives reason for remaining faithful to a "divided discipline". The momentum of theoretical plurality should be embraced as an innovative move of *discovering and exploring new dimensions, scopes, and complexities of existence as relevant for IR*. The fruits of these discoveries, of course, demand the hard work of processing. It is not without efforts to incorporate them into the body of accepted puzzles and theories. World-views have to be corrected; theoretical frameworks need be adopted and so on. Stretching the traditional boundaries of IR also requires enormous efforts of intellectual persuasion, bridging conversations, and inter-paradigm "translations" (Busser and Wegner 2012, cf. Kuhn 1970, p. 202ff.).

To some extent this is already occurring. The ramifications of opening up Pandora's box are exemplary, as illustrated by the field of security studies. Steven Walt's (1991) attempt to keep the flood gate closed notwithstanding, the spread of security concepts, concerns, and actors, has almost violently forced "security studies" to accommodate to broadening, deepening, and multiplying of the "stuff" of security (Lipschutz 1995, Smith 1999, Fierke 2007, Booth 2007b, Dillon and Lobo-Guerrero 2008, Buzan and Hansen 2009, Aradau 2010). Due to this sustained momentum, it is not by coincidence that especially the field of "critical security studies" is most furiously pushing the envelope of IR theories.

Explorative realism extends and supports this kind of ontological widening in specific ways. It agrees with pragmatic thinking that "gladiator style" research has entirely lost its appeal (Friedrichs and Kratochwil 2009, Sil and Katzenstein 2010). The increasing plurality of theoretical perspectives, which has already been a feature of IR during the interwar period, has lessened the epistemological dominance of positivist approaches embodied in Neorealism and Neoinstitutionalism to a certain degree. As Cochran notes, a historical chance, related to methodological pluralism, exists for the "broadening of our understanding of what international relations is, opening the range of possible ontological claims" (Cochran 2009, p. 147). The "blossoming of a hundred flowers" is not just the analytically most productive way forward as pragmatism suggests. Learning, among others, from Vandana Shiva and Boaventura de Sousa Santos, we have to value the diversification of philosophical foundations also for ethical reasons.

Ontological homogeneity in IR produces narrow-minded research agendas, policy advice, and sometimes policies. The conditions of possibility for monocultures, ultimately, depend upon willful blindness against alternative ontologies (Shiva 1994, de Santos Sousa 2004, 2005). As such, monoculture puts the community of researchers into a fairly troubled position (Smith 2004).

From the view of philosophy of science, however, critical research does not necessarily require embarking on the postcolonial, the anti-western, the subaltern realist, or the anti-neoliberal camp. It would suffice shifting the epistemology-focused debates to ontological concerns by means, for instance, of a playful and agnostic employment of foundational collectors. Capturing the gist of post-foundational times from a Kuhnian perspective, then, means taking theory seriously as a device for discovering and exploring new empirical landscapes. As such, the anti-positivist tenet at the core of many feminist, postcolonial, and post-structural studies has from the very beginning contained an emphasis on redirecting our attention away from epistemological battles. Quite a few scholars, arguably at the margins of IR, entertain the ambition to push ontological frontiers outwards. In Chapter 5 I lay out my own approach to ontological expansions suited for studying technological innovations—inspired by Cox's, Strange's and Enloe's monumental inroads und drawing on other extra-disciplinary sources. Prior to that, the next section will briefly discuss the epistemological position that accommodates explorative realism.

6.3 The practice of knowing: from matters of concern to matters of fact

Turning the simultaneity of mutually exclusive philosophical foundations into a virtue, I have stressed the "explorative function" of theories. Supposed that we have accomplished the task of assembling the multiplicity of a particular case of technological innovation, what does explorative realism imply for the solidity of our acquired knowledge? Would not legitimizing theoretical diversity in the sense proposed here ultimately amount to relativism? Influential IR schools certainly suggest so. For example, King, Keohane and Verba (1994) have argued in their account of scientific inquiry that positivist standards would ensure the validity and comparability of research projects. Only the use of quantifiable variable-based models and assuming causal relationships between "observable patters of observables" would ensure added value and substantiate claims about the truth (Kurki 2006, p. 196). When this is not the case, such as with post-structuralism, the value of scientific knowledge is nullified. Indeed, post-structuralist or feminist writings are often not referred to as scientific knowledge because the lack of "internal validity" threatens the root of scientific "dignity". For, as Mercado (2009, p. 482) states, scientists should be able to "lay claim to any more respectability than the political insights of a Churchill, a Kissinger, a Kennan."

The central point, though, lies in overcoming the misleading claims that one can either have reliable knowledge, through epistemological mono-cultures or multi-perspectivism coupled with "relative", that is, unscientific knowledge. On the one hand, various philosophers of science reject calls for scientific monocultures for good reasons. A single foundation or paradigm neither delivers an unproblematic guarantee nor a sufficient condition for the possibility of reliable truth-claims that differentiate between practitioners' insights and scholarly knowledge (Feyerabend 1975, Lakatos and Musgrave 1970). On the other hand, pragmatic scholars emphasize that the validity and the reliability of knowledge is instead achieved through diverse scholarly procedures of judging, selecting, evaluating, and affirming research methods and results (Friedrichs and Kratochwil 2009, pp. 214-217).

Pragmatism notwithstanding, we cannot refute so easily the accusation that a pragmatic epistemology, lastly, still amounts to relativism. In times of a foundational crisis, or so it seems, one cannot but become a relativist (Kuhn 1970, pp. 240ff.). This ultimately is also the essence of post-foundational reasoning (Monteiro and Ruby 2009a, 2009b). However, it seems to me, the plea for post-foundational attitudes would be premature if it involved the claim that solid knowledge is impossible to achieve. The notion of a post-foundational attitude of the kind, which Monteiro and Ruby advocate is self-contradictory. For if we consider all philosophical foundations in IR—just as their relatives from the philosophy of science—as shaky and disputable because they demand committing acts of belief, is this not a foundational claim in itself? Particularly, this would establish that we could never escape knowledge uncertainties in social science. After all, such would be the implication of Monteiro and Ruby's (2009a, p. 18) notion of “foundational prudence”. Accordingly, they suggest adopting an “attitude” rather than a “position” for which one potentially might wage academic wars over foundations. Foundational prudence implies that we cannot and should not validate, or for that, rule out, paradigmatic perspectives, analytical designs, and research results solely on the basis of their philosophical underpinnings (Monteiro and Ruby 2009a, p. 39). To sum up, the contemporary debate has us believing that we have to choose between Scylla and Charybdis: Either we say farewell to scientific facts or we surrender to a commonwealth of foundational monoculture.

This dichotomy represents a false choice as will become perfectly clear in the course of this section. At the core of it lies what I will call a Cartesian move. The basic tenets of Cartesianism, that is, the mind-matter divide and the inevitable gap between intellectual speculation and the material world, are still ingrained in the research practice of social sciences, our conceptual language, and our meta-theoretical commitments in so many different ways that it seems nearly inescapable (Foucault 2005, Latour 1993, 1999b). Establishing a post-Cartesian approach to IR, whatever this means (e.g. Pouliot 2010, Wendt 2004), is simpler said than done. One might even wonder whether IR can be saved if we give up Cartesianism. Explorative realism thus is not *the* solution but merely attempts to contribute to a post-Cartesian solution for epistemology.

The first point that needs to be acknowledged is that scientific knowledge is manufactured. This does not preclude us from speaking about “matters of fact”. One should not mistake the understanding of construction for a deconstructionist project. Understanding how sound knowledge is attainable instead requires us to substitute a number of commonplace dichotomies such as mind vs. matter or reflective reason vs. material causality that have rendered epistemology a confusing enterprise. On that ground, I reject contenders of foundational hegemony in IR—critical realism, social constructivism, and pragmatism that claim to offer consistent elements of a philosophical fundament. The decisive epistemological point to notice, which I draw from science and technology studies, is that only the proper fabrication of knowledge—that entails multiple relations/associations among colleagues, data, institutions, theoretical concepts, instruments, et cetera—explains the occurrence of the hard icons of scientific progress (Pickering 1995, Latour 1999a).

There are Cartesian misconceptions abound. “Brute facts” are not mysterious entities that must be extracted somehow from “external reality” as critical realism would have us believing (Searle 1995). Nor do scientific facts refer to observable regularities as Humean brands of positivism claim. No more do I agree that (social) facts, ultimately, are “ideas all the way down” because of their entirely subjective or discursive construction as Wendt’s (1999) social constructivism proposes. The reason is that the epistemology-driven views which dominate IR overlook an important issue: we can inquire, observe, and describe the various *relations* that characterize scientific construction practices (Shakley and Wynne 1996). This is, for example, evident from the politics of climate change (Demeritt 2001, Miller 2004, Mayer 2012a) and from the emergence of “failed states” (Bueger and Bethke 2013). Here, it is crucial to understand that “relational” or “relativist” are not just buzzwords, but rather help to explain why matters of fact exist at all (Latour 1999a). In short, a realistic view on the *relational* nature of research and knowledge production is against commonsense within IR.

To begin with, peer review constitutes today’s predominant validation practice. However, the discussion among IR scholars, except pragmatist views, widely ignores that peer review provides a respected validation procedure involved in the creation of matters of fact. It is practiced across a large array of disciplines and apparently not inhibited from the parallelism of different foundational positions. But to sustain it as a process-based solution to thorny epistemological problems poses huge challenges to epistemology. While peer review amounts to an additive process that entails multiple actors with several foundational occupations, it nevertheless often gets under attack for exclusionary tendencies that threaten to silence alternative, yet supposedly valid bodies of knowledge (Edwards and Schneider 2001). In short, hidden or exposed foundations bear on the “internal” politics of research funding, publication policies, and career paths (Kurki 2009). Moreover, as soon as scientific knowledge enters the field of policy advice the validation process additionally embodies “external” political interests. This brings me to my second point: In the context of scientific practices such as in the case of climate change research the foundational claims of scientists and their contradictions became political weapons in the hands of skeptical politicians, political lobbies and an often confused public (Demeritt 2006, Jasanoff 2003). Conversely, certain theoretical discourses are distinct from their alternatives in as much as they are intermingled with certain realities. IR theories are practices because, as Ashley notes, "the predicament it portrays and takes to be foundational is actively produced in history and through practice." (Ashley 1988, p. 228)

This brings science into a trouble position. On the one hand, if scientists resemble "honest brokers", as Roger Pielke proposes, they have to present different choices to the public *including* the inherent insecurity of models, data limitations, conceptual biases, and thus more generally their foundational beliefs (Pielke 2008). On the other hand, the practice of scientific knowledge validation usually operates not only within a scientific community, but also within a larger political and economic environment. This inevitably bears on the status of matters of fact as climate change research amply illustrates (Hulme 2009, Jasanoff 2004b). For pragmatists, thus, the example of other disciplines significantly complicates the picture, because it diminishes the promise of "useful" knowledge against the backdrop of rampant epistemological politics. At the same time, pragmatists have not proposed tools that help closing a scientific debate in which "politics" and "science" can never be sorted out (see Friedrichs and Kratochwil 2009). This leads to a seemingly thorny question: do we eventually have no other choice as to "deconstruct" scientific knowledge—for it is, in addition to its relative character, often politically biased?

The answer is a cautious "no" because we are stuck in a Cartesian fog of war here. Fortunately, IR theory does not need to invent the wheel anew. Opting against unrestricted deconstruction, explorative realism—following approaches in science and technology studies (STS)—is based on the believe that we should not reduce the problem of sound knowledge to Descartes' puzzling about the human mind-matter divide that has so much influenced modern European thought. Rather, it aims at observing what actually happens at the sites of knowledge construction, where concerns are turned into facts in the first place (Latour 2005, p. 91). Similarly, Feyerabend's slogan "anything goes" is not a postmodernist's epistemological cry out of the blue. Rather, "anything goes" reflects Feyerabend's careful observation of the empirical reality of scientific progress (Feyerabend 1975, chap. 1). The key lesson of philosophy of science holds that only after ascertaining through which processes scientific knowledge is being established, we should construct a theory of knowledge. Accordingly, my notion prefers ontological insecurity to an epistemologically imposed order. It privileges cautious description over undisturbed prescription—a stance, however, running against most recent attempts to find a philosophical grounding for IR. In short, I treat epistemological questions first and foremost as an issue of *scientific practice*.

Explorative realism suggests symmetrically interrogating the performances entailing collective action, material objects, theories and ideas, while avoiding an overemphasis on ideal, textual, and linguistic dimensions. What this means is best explained by how the understanding of epistemology did evolve within science and technology studies. It contrasts with IR perspectives about how "reality" is accessed and which theory of knowledge is appropriate. In order to clarify my own epistemology, it is useful to follow the principle of "symmetry" that is central in STS debates about epistemology while mentioning various other lines of arguments when necessary. The Edinburgh School introduced the postulate of "symmetry" in the 1970s against the widespread assumption in the science studies community that "true scientific beliefs" correctly refer to objective reality while false beliefs follow from biased political or social influences (Bloor 1976). The main protagonist, David Bloor, stated "both true and false, and rational and irrational ideas, in as far as they are collectively held, should all equally be the object of sociological curiosity, and should all be explained by reference to the same kinds of cause." (Bloor 1999, p. 84) This implied a radical rejection of crude forms of naturalism that were prevailing at that time. However, a subsequent generation of scholars placed this line of argument under scrutiny for the reason that it reiterated the classical subject-object distinction. In addition, they criticized that Bloor sustained the correspondence model of scientific knowledge as an integral component (Bloor 1999, Latour 1999b). This notion presupposes, to use Bruno Latour's ironic metaphor, an unbridgeable gap between the "things-in-themselves" and the "mind-in-a-vat" (Latour 1999a, p. 4).

The idea that juxtaposes an isolated mind and reality "out there" constitutes a constructivist narrative that underlies European philosophy and meta-theory—beginning at least with René Descartes but carried with different accentuations from Hume to Kant and even further to post-structuralists such as Derrida (Latour 1999a). The correspondence model is employed and accepted in many sciences—in IR especially by positivist or rational approaches while opposed by pragmatist approaches. Among the tenets of this knowledge theory is the idea that indisputable knowledge only resides in the individual mind and in its thinking activities that are isolated from the outside world of material things. So, to the extent to which it was Descartes' philosophical heritage, this "great divide" also resounded in the approach of the Edinburgh School, which put its focus on "social" explanations. Ultimately, much like in IR today, the notion that material objects could influence scientific explanations and philosophical reflections through their own agential power was totally excluded.

STS scholars searched for an alternative principle of symmetry. They were step by step exploring a new methodology and conceptual vocabulary. In as much as they were moving away from transcendental idealism, it was a result of their research work about laboratories and technological systems. Crucially, they assumed the potential of agency in both material objects (nature) and scientists (society). Different varieties of this sort of symmetrical methodology were applied to numerous cases of laboratory and historical studies of technological systems (Latour 1987, Lynch and Woolgar 1990, Bijker and Law 1992, Law 1987). The exploration of scientific practices revealed that numerous theories of knowledge were simply entertaining incorrect and idealized assumptions. This added new empirical evidence to Paul Feyerabend's earlier assessment that Popper's and Lakatos accounts of scientific progress were too simplistic (Feyerabend 1975, chap. 16 and 17). For example, STS showed that the subject-object schema is misleading and implausible. Furthermore, what is usually conceived as ahistorical facts actually has a history itself. Facts do not possess a hard shell but rather are products of a process of hardening, which involves various actors inside and outside of a laboratory. In other words, scientific facts move along an axis from instability to stability (Latour 1988, 1999a, 1999b).[112] Science and technology studies show that it is misleading to assume a sharp distinction between "facts" about which *S*cience—with a capital s—speaks, representing the objective matter, and "values" that are ever contingent, purely constructed outcomes of political processes. In scientific practice "language", "symbols,"

[112] Ludwik Fleck (1947) was an early predecessor, who put forward a similar observation when he explored the "Denk-Kollektive" that was part of finding a new drug substance.

and “nature” are inexorably intertwined.[113]

In sum, investigating the scientific praxis progressively renders several ideal-type models of science untenable that underpin theories of knowledge. Matters of fact exist, but they are not timelessly given and discovered in the “outside world”. Rather, they are a product of numerous relations and negotiations involving human agency, material entities, artificial objects, ideas, concepts, measurement devices, standardization, and so on. This offers a fascinating portray of the world in which little is left of the traditional delimitations of the “social” and the “natural” (Latour 1988, 1992, Stenger 1997). A post-Cartesian theory of knowledge thus begins by taking real knowledge for multiple relationships instead of Descartes’ puzzle of doubtful minds, which are isolated from the world (and their bodies).

Subject — — — — — — — — — — Object	
(Reasoning subjects with agency)	*(Material objects without history)*
Matter of fact —————————— Matter of concern	
(Stably assembled reality)	*(Unstable claims, start of assembling)*

FIGURE 6.2 TWO MODELS OF KNOWLEDGE CLAIMS AND KNOWLEDGE PRODUCTION

What are the consequences of the relational epistemology if neither objectivist (“materialist”) nor critical-deconstructivist (“vanguardist”) rationales underpin truth claims? Is our knowledge consequently entirely arbitrary—that is, are IR theories fully contingent, in particular, dependent upon political interests, directed by funding, or dictated by shifting scholarly conventions? Are theories, finally, not distinguishable from myths as Paul Feyerabend claims even for theoretical perspectives of other “hard sciences”? The most plausible answer to these questions is first that scientific facts and

[113] See Latour and Woolgar (1979), Knorr Cetina and Mulkay (1983), Lynch and Woolgar (1990), Pickering (1992, 1995).

myths are distinguishable because they are constructed and maintained differently (Latour 2012). And, secondly, scientific knowledge is contingent but not random. Matters of fact are constructed for good reasons and with much care and effort. In contrast to correspondence models of knowledge, this approach first of all observes and specifies all efforts and acts of care. As Christian Bueger argues, we relate things, ideas, and people, make chains of arguments that have to be stabilized and translated—from the collection of various "data", to the interrogation with fellow colleagues and the writing onto pages or typing into laptops, to publishing in journals and books (Bueger and Gadinger 2007, Bueger 2012). But IR does not only comprise the social activity of "research as the consensus-oriented practice of discursive communities" (Friedrichs and Kratochwil 2009, p. 214). It also involves various artifacts, virtual technologies, recalcitrant "data", and various strings that reach outside our laboratories (which is our texts and offices) including university politics, funding mechanisms, policy advocacy, fieldwork informants and so on. If we would fail to keep up all these chains of translations and would stop integrating, and accommodating to, new actors no single truth claim would ever survive.[114]

Inevitably, it follows that research results can never be evaluated according to "objective" or "subjective" standards in the sense of Max Weber's *Werturteilsfreiheit* (Weber 1985) – yet not because of intractable complex realities as Patomäki and Wight indicate (2000). The reason that the fact-value distinction makes no sense is that the very networking practices by stabilizing knowledge are constantly interweaving value arguments and factual claims as a matter of necessity. "Matters of fact" thus emerge from collective practices that relate—across the domains we think of as neatly separated—texts on journal pages, concerns between colleagues, artifacts, empirical data, public controversies, metaphorical rhetoric, and policy relevancy. This is to say that scientific disciplines shape the world as much as the world shapes their research (MacKenzie 2006, Mitchell 2005). In brief, a post-Cartesian theory of knowledge would not be concerned with the arcane problem of ascertaining knowledge claims about the "outside" world

[114] This also appears underpinning the notion of integrative or transdisciplinary research, which characterizes the burgeoning scientific fields of earth-system research, geography, climate, linguistics, engineering, and computer sciences See Nowotny, Scott, and Gibbons (2001), Zimmerer and Basset (2003), Russell, Wickson, and Carew (2008).

across mind-world chasms. Epistemology rather is about assembling and associating all the way down. The key concern of explorative realism, hence, is the question as to whether *the construction of knowledge is well done* (Latour 1999a).[115]

Testing the solidity of knowledge, in this sense, involves a set of evaluation criteria, which set explorative realism apart from other philosophical foundations. First, the question whether something does actually really exist—for instance as scientific realists are concerned with the status of theories, which should be closely corresponding with reality (Wight 2007)—is meaningless. Reality is simply not separated from knowing and our minds are neither isolated, nor the only locations of knowledge production and validation. Observing the multiple entanglements with artifacts, systems, algorithms, and so on that render our lives real and scientific knowledge credible, we should simply discard the mysterious Cartesian contemplation that doubts existence and frames secure knowledge as a matter of dreaming (Latour 2005, p. 103). The real task is instead to ethnographically explore whether and how these entanglements unavoidable within a technological world are relevant for IR. Inspiration for this kind of research flows from STS, sociology, geography and first of all anthropology that methodically tries to avoid modern dichotomies (see Shaw 2003).

Second, our core analytical interest is not concerned with constitutive or causal explanations—in whichever of its versions (Waltz 1979, Wendt 1987, Hollis and Smith 1990, Kurki 2006)—but how theoretical notions and analytical concepts help us assembling the multiplicity of the world. This comes down to the mentioned explorative function of theories. Especially with respect to technologies, the discussion in Chapter 2 has shown that we lack conceptual approaches that capture the agency for artifacts without relying on determinism. How to understand and conceptualize things as

[115] This is the opposite of "social constructivism". To cite Latour: "'constructivism' should not be confused with 'social constructivism'. When we say that a fact is constructed, we simply mean that we account for the solid objective reality by mobilizing various entities whose assemblage could fail; 'social constructivism' means, on the other hand, that we replace what this reality is made of with some other stuff, the social in which it is 'really' built. An account about the heterogeneous genesis of a building is substituted by another one, dealing with the homogeneous social matter in which it is built. To bring constructivism back to its feet, it's enough to see that once social means again association, the whole idea of a building made of social stuff vanishes. For any construction to take place non-human entities have to play the major role and this is just what we wanted to say from the beginning with this rather innocuous word" (Latour 2005, pp. 91-92).

“mediators” is thus a key question. Theories must help to multiply actors and agency without employing short cuts such as social structures or else (Latour 2005, p. 240). This is the meaning of “explaining” according to explorative realism.

Third, we need to modify the notion of *mathesis*. Descartes had suggested defining reliable knowledge exclusively in terms of discrimination, that is, a method that “imposes upon comparison the primary and fundamental investigation of difference” (Foucault 2005, p. 63). Yet, qualifying the most fundamental element of Cartesian thought remains complicated. Specifically, the (conceptual) order of difference that, in accordance with Cartesian understandings must be imposed on the world, should be turned into an open question—an empirical questioning sensible to the fundamental difficulties of discerning ‘identity’ and, hence, ‘difference’ in the first place. We cannot go beyond Descartes’ notion of difference entirely. But we should pose ‘identity’ as a question for empirical inquiry. Consequently, the dynamic *relationships* between agents, the replacement of qualities, agencies, and shapes, and the shifting *agency* of and within collectives move to center stage. If concepts such as “power”, “sovereignty”, or “states” are not framed in a way as to enable us to capture the reshuffling of identities and differences in the world we ought better drop them.

One of the core issues at stake is precisely captured by the notion of “methodological nationalism” and John Agnew’s “territorial trap” (Agnew 1994, Wimmer and Glick Schiller 2002, Ferguson and Mansbach 2007). What the sociologists Beck and Beck-Gernsheim write about their discipline applies perfectly to IR as well:

> “methodological nationalism involves much more than just a problem of empirical data, which are largely collected and analysed on a nation state basis and compared internationally. Much more profoundly it is about how the core sociological concept of generation (like the concepts of social inequality, the state, the family, the household, justice, neighbourhood, etc.) can be liberated from the mental horizon of methodological nationalism and opened up to the fundamental transformations of globalized Second Modernity. Where this does not happen, the lived reality of the rising generations will remain terra incognita—no matter how much data the social researchers gather.“ (Beck and Beck-Gernsheim 2009, pp. 34-35)

In this sense, critical realists in IR—referring mainly to John Searle’s or to Roy

Bhaskar's thoughts[116]—point in the right direction by claiming that the status of our knowledge must be open-ended, not absolute, because it reflects an ever-changing reality (Patomäki and Wight 2000, Jackson 2008, Wight 2006, 2007). Yet, even if critical realists want to abandon the "level of analysis" assumption and the simple opposition of agents and structures, their realism is not radical enough. They continue maintaining metaphysical orders of difference without observational evidence. These arbitrary "orders" of stratification include the divide between social and material worlds mentioned above (Patomäki and Wight 2000, Wendt 1999) that cannot be justified empirically—particularly due to the technoscientific reality that we experience. Even approaches more sensitive to material agency ultimately maintain a dualistic understanding (e.g. Wight 2006, pp. 295ff.) and, hence, by reinforcing the fundamental chasm (Weber 2012) reintroduce a prefixed ontology.

Fourth, knowledge production cannot be evaluated and legitimized by means of its alleged contribution to the cumulative growth of disciplined bodies of knowledge. Explorative realism here contests Popperian or Lakatian understandings. The idea that accumulated academic knowledge can authoritatively speak about regularities and discover laws seems unrealistic due to the diversity of solid knowledge. Its realization is even not thinkable, as critical realism and social constructivism argue against positivism, through an infinite process of accumulation (Kurki 2006, p. 193, Searle 1995). One reason is that such an argument must, as the condition of possibility, take recourse to an "outside" world that gets described cumulatively. This means, however, to hold up the Cartesian division between minds and facts. Another reason to reject the idea of accumulation is the fact that we live in multiple ontologies as archeologists and sociologists affirm (Mol 2002, Dobres 2010).

Fifth, we can nevertheless attempt to order empirical observations by establishing taxonomies or putting collections of data and puzzles into their proper place. For that to happen, we must not only assure that our "categorical order" derives from careful observation and thick description of reality rather than from positivist "as if" assumptions, logo-centric prescriptions, or Kantian a priori. It is possible if we do not

[116] See Archer, Bhaskar, Collier, Lawson, and Norrie (1998) and Searle (1995).

mistake the map as a representation of the landscape. The fundamental issue at stake here is to keep taxonomies open-ended, instable, and in the form of an infra-language. It also requires making transparent and explicit the Cartesian-inspired purification practices that cut through the relationships of a subject matter and its environment (Foucault 2005, p. 142, Latour 1993).[117] To the extent to which we overcome Cartesian mathesis we really begin to grasp how "purifying" does not only allow for theoretical parsimony, but does also lead to fundamental flaws of our conceptual language. In turn, it is a methodological and a meta-theoretical obstacle, which limits our comprehension of real multiplicities. Its high cost can never be highlighted enough. Most IR theories, as Enloe for instance points out, have systematically "under-estimated the amount and varieties of power at work." (Enloe 2000, p. 197) Overcoming the traps of purification, therefore, demands an "infra-language" (Latour) for both analytical practice and theoretical conceptualizations. For instance, post-Cartesian accounts employ a symmetrical reading of what has previously been treated separately as material "forces" and human "agency". In addition, Descartes' heritage, while enshrining the difference between mind and matter, first and foremost does foreground reasoning and speculation over perception and entanglements. The quantum-ontology by which means Alexander Wendt aims at rebuilding the ontological fundaments of his *Social Theory* (Wendt 2004, p. 189) is thus in some respects even more Cartesian than his initial approach.[118]

Sixth, explorative realism requires a differentiated understanding of the role that language plays for the construction and application of IR theories. It is important to recapitulate the role that Descartes' model of knowledge has granted to language. Forged hundreds of years ago in the age of representation, the assumed gap between words and things has made it possible in the first place that "things touch against the banks of

[117] At this point, my wording will perhaps irritate the reader. It is treacherous. For it seemingly goes without noticing: social scientists almost automatically accept that a thing/subject matter/unit of analysis has a context or an environment. Exactly this order of difference, Descartes' powerful bequest, that we are used to apply to our subject matter, is what we need to abandon if we want to seriously inquire into the politics of technological innovations.

[118] As such, Alexander Wendt's proposed "quantum social science", which allegedly differs from Cartesian social science by virtue of its "dual quality of quantum ontology" (Wendt 2004, pp. 200ff), is misleading. From explorative realism, it is unconvincing to radically remake only the physical basis of the human consciousness, whereas the rest of the "order", namely Wendt's three levels of individual, society and international system, just remains intact and, hence, as we have seen without any substantial matter.

discourse because they appear in the hollow space of representation." Michel Foucault argues that in the age of similitude, words used to be "interwoven in the very being of the beast". At the time of Descartes, however, "they have been unraveled and removed: and the living being, in its anatomy, its form, its habits, its birth and death, appears as though stripped naked" as Foucault puts it (Foucault 2005, p. 141). This primordial heritage still to some degree underpins correspondence-theories of knowledge and other foundational commitments. While words and signs prior to Descartes were usually seen as interrelated and interwoven with meaning, practices, the creation, and artificial objects, the Cartesian mathesis purported a neat split reality: "on the one side, we shall find the signs that have become tools of analysis, marks of identity and difference, principles whereby things can be reduced to order, keys for a taxonomy; and, on the other, the empirical and murmuring resemblance of things, that unreacting similitude that lies beneath thought and furnishes the infinite raw material for divisions and distributions." (Foucault 2005, p. 64)

As in the case of Diderot's *Encyclopedia*, where the missing ability of language to express experience led to considerable problems, the issue of language has serious implications for IR. Fierke argues that meta-theory in IR is strongly influenced by two different late-modern language theories. Language has been relegated to the margins of the discipline due to positivist epistemological presuppositions that base their knowledge claims on a practice that excludes language both as concern of research and with regard to meta-theory (Fierke 2003). On the one hand, positivist and rationalist approaches aligned with the early Wittgenstein, who left open the possibility that words still could somewhat resemble the real things. Post-structuralists, on the other hand, took on the late Wittgenstein who emphasized language as a game that is unrelated to reality (Fierke 2003, pp. 74-79). An explorative realist perspective, however, calls into question the meta-theoretical commitments, which made possible in the first place that language became singled out from reality and was deemed merely instrumental for representing the "outside world". Instead, language is constantly travelling and "border-crossing". This may contradict textbook accounts of social science. But it is prevalent to the extent that the boundaries of different domains become blurred. The connecting performance of words, concepts, signs, and narratives attract our core empirical interest in itself (Bueger and Villumsen 2007). As a consequence, any consistent theory of knowledge must comprehend the mutual participatory logic of entanglements between “scientific knowledge”, “theories” and “lay knowledge”. This can lead to the adoption of “emic concepts” (Brislin 1976), a term that refers to the vocabulary used by actors themselves to make sense of what, why and how they are interacting; it certainly implies the deliberate collapse of the theory-practice distinction (Villumsen Berling 2011, Caliskan and Callon 2010). As noted in the introduction we find a closely related emergence of new concepts and actual economic realities the field technology and research policy (Godin 2002, 2006).

Overall, explorative realism implies an understanding of knowledge that aims at fully apprehending the practice of knowing without unraveling into a de-constructivist attitude that strives to debunk power, interests, or ideology as forces allegedly luring behind scientific knowledge. Instead, the practice of knowledge making amounts to “collecting them into one collective.” (Latour 2005, p. 256) Explorative realism acknowledges that network practices collect from the diversity of things and stabilize matters of fact. It lays out a set of criteria in order to judge whether the construction of our knowledge is good or bad. Thus, it does not respond to the perennial Cartesian concern whether knowledge is true of false. As outlined above, six criteria are paramount for the attempt to transcend Cartesian thinking—an ethnographical attitude, explorative theorizing, difference as empirical question, conceptual infra-language and avoiding purification, the collapse of language and “context”. Together, this translates into concrete methodological measures summarized in the following.

6.4 Methodological ‘limbos’ and the post-Cartesian toolbox

If we assume that the traditional ontological boundaries are too restricted, how could we account for additional levels and dimensions of reality? Explorative realism, first of all, involves a move that *merges theoretical insecurity with research methods*. The reason technological innovations pose challenges to research is because common conceptual dichotomies fall short in capturing their real intricacies. Against this backdrop, methods such as thick description (Geertz 1973), ethnomethodology (Garfinkel 2002, Maynard and Clayman 1991), and Actor-network Theory (ANT) (Mol 2012, Barry 2001, Latour

2005) provide us with tools of inquiry that do not take any categories for granted and lead away from prescriptive social science. In this vein, Bruno Latour argues, “anthropologists, who had to deal with premoderns and were not requested as much to imitate natural sciences, were more fortunate and allowed their actors to deploy a much richer world. In many ways, ANT is simply an attempt to allow the members of contemporary society to have as much leeway in defining themselves as that offered by ethnographers. If, as I claim, ‘we have never been modern’, sociology could finally become as good as Anthropology” (Latour 2005, p. 41).

James Der Derian, who investigates the interplay between technological innovations and war perhaps more closely than any other IR scholar, emphatically reaffirms this view. Recalling his seminal research into the hybridization of war, ethics, virtual technology, and media-entertainment, a complex that he labels “virtuous war”, he notes about maps:

> “As I went deeper into the MIME-NET, the more often I felt the need to leave the map behind, not because it was flawed but because it was taking me to the wrong place, in which the illusion of command and control squeezed out the rich contingencies of life. In short, I'd rather get lost, at some subliminal level, than end up where the map was taking me. (...) Looking back on my efforts to map the military-industrial-media-entertainment network, I realize that getting lost produced some of the most important insights. (...) Getting lost forced me to reconsider the interdependent relationship between map-making and map-reading; it illuminated the shadow space between the landscape and the map, revealing why and how the modern map-reader would prefer the inaccurate map to a recalcitrant landscape. In my travels I often found the most interesting perspective—and interesting people—at the edge of the map, where the monster lurk, where the distinction between the representation and the real thing begins to break down but is not yet overwhelming.” (Der Derian 2009, pp. 279-280)

This vivid description comes close to Galison’s “critical opalescence” that we have encountered in the second chapter. Like Galison (2006), Der Derian stresses the inexorable mingle of reality that seems bottomless. Analytically, he makes no attempt to foreground “social” actors over technologies or vice versa. He tries to circumvent the very dualism of these notions. In Der Derian’s sensitive reading, the lines between military strategy, public relations, pictures, computer-simulation, soldiers, virtually augmented battlefields, and the muddling-through of global high-tech warfare are blurred or have collapsed entirely (Der Derian 2009). Through his methodological attitude Der Derian stresses a fundamental insecurity about a world filled with real-virtual, human-cyborgs, war-entertainment, and virtuous violence reality where we are getting lost and our categories easily become fuzzy.

Interestingly, these observations reverse the ontology-epistemology nexus as it is often discussed within IR (see Kratochwil 2000, Wendt 1999). The predominant epistemological concern is no longer the legitimacy of scientific truth-claims, but whether a theory of knowledge enables the comprehension of a complex reality. The function of foundational collectors is thus to open up windows into complexity instead of foreclosing them for the sake of parsimonious puzzles or usable expertise (Der Derian 1990). Its prominence among many anthropologists and critical geographers notwithstanding, this sort of sensitivity, arguably, is of limited appeal to IR scholarship.

The sense of deep insecurity that persists because the researcher deliberately avoids presupposing any specific order of difference constitutes what I want to call "limbo".[119] In relation to epistemology, the idea of limbo conveys two meanings here. First, it denotes the mind-set at the starting point of research that is not tempted towards reductionism but aims at unearthing unexpected differences. Turned into a methodical guide, limbo suggests probing into unstable/stabilizing differences and heterogeneous identities through empirical tests. This implies three complementary paths of exploration: 1) Exploring controversies about agency, group-belonging, and fact/value distinctions (Venturini 2010, Barry 2012, Jasanoff 2011). 2) Following the circulation of things, their movements, fluidity, agency, and employment within and across collectives. 3) Following human actors in their engagements within collectives and their shifting agency during processes of assembling and reassembling (Latour 1987, Law 2004). Obviously, these paths require not only a considerable conceptual repertoire, but also the full range of empirical research methods including ethological fieldwork, observational research, extensive interviews, and archival studies.

[119] Thanks to discussion with Peer Schouten for attending me to this term.

The other meaning of limbo refers to the status of knowledge itself, which is in a phase of stabilization and thus prone to disruption, translations, and shifts. This comes close to the understanding of theory that Annemarie Mol suggests: "a 'theory' does not necessarily offer a coherent framework, but may as well be an adaptable, open repository. A list of terms. A set of sensitivities." (Mol 2012, p. 265) If we assume a gradient between limbo (the concerns at the beginning of our research activities) and the matters of fact that should be its end point, then theory is flexible and adaptive in order to enable the navigation through a complex landscape. Rejecting the object-subject schema frees us from the obstacles and intricacies of correspondence models of knowledge. As a consequence, scholars do not impose hierarchical research methods onto their "objects". However, this does not imply that consistency in our conceptualizations and precise empirical work is no longer warranted—the opposite is true.

The important point here is that practices of empirical research and "theory" are not separated in the first place. Instead, the methodology of explorative realism assumes that we *can easily* relate and associate with actors and follow their relations. There is simply no prima facie reason to anticipate limits of access, as Kantian constructivism would content. In contrast to critics of using ethnographical methods in IR, it is plausible assuming that we can listen and talk to people, can observe and participate in processes and practices. Simply, we can become *entangled* in networks of humans and non-humans in multiple ways. Sound knowledge actually is *always* based on mingling with and possibly changing thereby the world that we want to explore—we contribute to the constitution of our subject matter in as much as the practitioners we engage with. Different forms of entanglement are unavoidable for conducting research and producing stable knowledge (Vrasti 2008, Rancatore 2010, Neumann 1996, 2011). Political engagement is normal and activism happens often—just consider the life experiences of Hume, the Humboldt brothers, Einstein, Heisenberg, Marx or Foucault. None of them has shied away from entanglement for a mistaken fear of distortion of "science".

In brief, entanglement is both a product and a condition of sound research. As historians of science have shown indeed, scholarship and reality have never been divided into two domains (Shapin and Schaffer 1985, Galison 2006). In practice, concepts and buzzwords are moving among diverse academic disciplines, the public, and political discourse back and forth. Ideas, metaphors, and theories do not only help to explain phenomena, they also, over time, strongly influence them and vice versa (Latour 2005, Polanyi 1943). In international politics, as in other fields, this relationship rather constitutes a two-way expressway and often a seamless web (Litfin 1994, Mitchell 2005). Similarly, classical traditions in IR are "constitutive rather than merely reflective forces in international politics (…) they are part of a constant making and unmaking of history through interrogation, interpretation, and narration." (Der Derian 2009, p. 301, Ashley 1988) By implication, the construction of scientific knowledge needs to be evaluated by its actual entanglement precisely because it does not only flourish in an isolated scientific domain. But it helps in fact with assembling the common reality.

Does this mean that explorative realism leads one to merely describing what is to be found in the field or what is perhaps the latest political fashion? The answer clearly is no. In contrast, explorative realism advances quite distinctive methodological motives. But let me shortly restate what it does not claim: it neither aims at finding regularities and correlations/causality as positivism suggests; nor does it have to introduce "counter-phenomenality" or "trans-phenomenality" as Wight (2004, p. 270) suggests with reference to Marx. The latter view presumes that critical social scientists resemble a kind of vanguard, who possesses deeper knowledge and thus can tell appearance from reality (Wight 2004). The imperative of such a claim to superior knowledge boils down to an anti-superstition priesthood that has never really tasted the limbo experience. Against vanguardism, I propose two alternatives: on the one hand, to learn from the visible and accessible controversies that occur when practices or collectives change or become unstable. This approach is post-Cartesian in the sense that it aims at a pre-disciplinary view questioning the validity of disciplinary boundaries. It is the opposite of the rigorous compartmentalization that belongs to the mainstream understandings of theory in IR. Regardless of whether the understanding of theory is a positivist, critical realist or constructivist one, the subject matter is always neatly divided and ordered to begin with (Smith 1996, Waltz 1997, Wight 2006, Wendt 1999). Instead, the state of limbo is suggested here as default position where methods and methodology collapse (Aradau and Huysmans 2013). It resembles a pre-disciplinary ontology in which Beate Jahn sees the great advantage of classical writers:

> "I think it is more promising to use a pre-disciplinary approach. I use a lot of classical authors and to me, the most valuable thing about classical theory is that a lot of it is pre-disciplinary. What does that mean? It means that these people did not actually start out from the assumption that economics was separate from politics and that politics was separate from, say, religion. And so, what you can get from classical theory is actually a theorization of the relations between all of these different dimensions of political life. That gives us a starting point in which these dimensions are connected. And we can then trace the fragmentation that arises subsequently, identify its roots but also the continuing connections that we miss when we begin with an already separated or fragmented point of view. (…) So, in classical texts, what strikes you most, is that politics, economics, religion, domestic and international are not separated from each other, and it gives you a good understanding of where society and international society is coming from in an integrated way. We can use classical theory to look at what actually inspired people to properly distinguish and separate out domestic from international politics: what actually led to the separation between politics and economics? And this is what we can't really do so easily when we start from today, because we're going to read the present fragmentation back into history." (Schouten 2012a)

On the other hand, I agree that there might be "hidden" things—yet quite different from a Marxist or critical realist understanding. The bottom line is that the big elephant in the room often resembles a black box that is taken for granted by actors and scholars alike. That is, it is stabilized to the extent that it functions as a mere intermediary. Contra Kantian idealism and methods of theoretical deduction, we therefore need to explore by empirical testing in situ which (human and non-human) actors really make a difference. Latour (2005) argues that finding out which actor figures as mediator and which one is an intermediary replaces theorizing invisible structures of the "social" and systemic forces of "structures".

The limitations of "theorizing" based on such an epistemology and methodology presented above are obvious. It does not lend support to notions of causal or constitutive explanations. It does not reveal hidden meanings. Nor does it examine intangible social forces or invisible structural power. In contrast, the task of foundational collectors can be summarized as follows. They should enable us to produce a thick and detailed description of the real multiplicity of the world without shortcuts. The promise of foundational collectors lies in their ability to assemble actors, agencies, and connections whose identity and differences are unclear or contested. Writes Latour:

> "All those questions are raised not only by scholars, but also by those they study. It is not that we, social scientists, know the answer that would reside behind the actors, nor is it the case that they, the famous 'actors themselves', know the answer. The fact is that no one has the answers—this is why they have to be collectively staged, stabilized, and revised. This is why the social sciences are so indispensable to the reassembling of the social. Without them we don't know what we have in common, we don't know through which connections we are associated together, and we would have no way to detect how we can live in the same common world." (Latour 2005, p. 138)

Ultimately, research should represent the collective to all its participants. The post-Cartesian twist that is involved here renders these textual accounts to transcend a purely "social" comprehension of the world. Against purified accounts by social scientists, the world is made to presents itself as various entanglements and networks of humans, animals, material things, ideas, images, language, and artifacts—a crazy mixture that cannot be separated without performing ontological violence. In this sense, thick descriptions pose a considerable task. They involve theoretical infra-language and require a methodological tool-kit that aims at generating research puzzles, typologies, and generalizing from phenomena in a mingled world.

This chapter has developed a post-Cartesian approach of how we access our subject matters. Any conceptualization of the politics of technological innovation can accordingly be assessed in two different ways: first, concerning its ability to capture insecure differences (of groupings, boundaries, agencies, facts, and so on) and, secondly, with respect to the extent to which it embodies the principle of symmetry. The idea of foundational collectors consequently breaks with the ontological logocentrism of IR theories. In short, explorative realism demands that we test empirically how *all sorts of actors*—and not just humans—relate to each other; it foregrounds process and hybrid elements in our collectives. How this can be undertaken in a conceptually systematic way with regard to technological innovations is developed in Chapter 7. A two-dimensional frame renders different options for ontological expansion intelligible.

7. Ontological expansion in the double-mixed zone

At the heart of explorative realism lies the task of expanding IR's ontological parameters. While my discussion ties into the ongoing conversation about the role granted to materials in IR's ontology (Connolly 2011, Coole 2013), I will employ a variety of different disciplinary literatures about technological innovations to develop a theoretical outlook that embraces heterogeneous forms of agency on the one hand and processes of emergence on the other. By ontology I refer broadly to both the assumed central features and 'actual' qualities of research subjects and the corresponding ontological building blocks that make up research and theory (see Furlong and Marsh 2010, Rescher 1996). In line with the methodological considerations detailed in Chapter 6, three interlinked subsections advance the argument for systematic ontological expansion. I draw on process philosophy, Schumpeter's evolutionary economics, and science and technology studies to sketch out accounts of material agency and processes of group formation (7.1-7.2).

These considerations are subsequently summarized in form of a two-dimensional matrix that helps to locate a post-Cartesian meta-theory. It aims at rendering intelligible the discipline's current ontological parameters and helps to chart the possibilities of ontological expansion. Approaches situated in the "double-mixed zone", in which processes of group formation and heterogeneous agencies form the primary notions underlying research concerns, are specifically suited to overcome the limitations of the IR approaches to technology (7.3). Conceptual vocabulary and empirical examples from other disciplines about technological innovations are utilized to animate the ontological component of explorative realism. Replacing the lightness of IR enables us to articulate an orientation for future research programs, covering multiple new issues, puzzles, and questions related to technological innovations and materially mediated processes of emergence writ large.

7.1 Heterogeneity and material agency

The first key to a post-Cartesian ontology lies in a differentiated understanding of agency that replaces the dualist notion of IR theories that either reduces agency to techno-determinism or to social reductionism. The latter rest on René Descartes' strict division between matter and mind. Perpetuated and reframed by various modern thinkers, it was handed down by Hume, Kant, and others (Latour 1993, 1999) and still has a considerable effect on current IR theories (see Patomäki and Wight 2000, pp. 219ff). As the deep analysis of *Man, State, and War* in Chapter 5 demonstrated, the construction of the current IR framework has escaped technological determinism only through imposing a rigid social world in which material artifacts make no significant difference. IR's privileging of social agents or human intentionality that sharply restricts ontology speaks to a long-standing logo-centric and "anti-realist" tradition within social sciences more generally (Braver 2007). As theorists concentrated on a purely "social" turf, all "natural", "physical", and/or "material" traits of reality were sorted out (see Latour 2005, p. 83, Barry 1999, Deudney 1999). Most conceptual frameworks reaffirm the social domain of symbols, meaning, rationality, or subjectivity, and while the prevalent conceptual language clearly shaped the boundaries of the proper domain as non-material (Mitchell 2002, Paterson 1995, Hovden 1999), only a few theorizations suggest otherwise.

Carroll provides an interesting option to replace the mind-matter divide in his analysis of the expansion of the modern British statehood on the Irish island. In describing the modern state formation, he avoids dualist conceptualizations such as "socio-nature" or "socio-technical". Instead, Carroll suggests granting the material, the semiotic, and the practical dimensions equal agential potential. Mapping these three dimensions onto the state produces a tripartite model comprising the state-idea, the state-country, and the state system. Writes Carroll:

> "All three dimensions of cultural formation—discourse, practice, materiality—can be granted their peculiar agential power, though in a manner, and this is a crucial point, that does not theoretically subordinate one dimension to the other. The relative agency of discourse (symbolic meaning, representation, and cognitive structure), practice (social activity variously organized), and materiality (constructed environments, spaces, and technologies) in processes of cultural formation can be treated as an empirical issue to be settled in each case by research." (Carroll 2006, pp. 14-15)

Analytically, Carroll suggests that state formation proceeds in three mutually embedded gravitational zones of social practices, symbolic discourse, and materials – this maintains a "reference to embeddedness and internal relatedness." (Carroll 2006) As he splits the world into three fields, he does not assume substantive differences between allegedly different worlds (materials vs. meanings) with other approaches from anthropology. Carroll's idea to study technical engineering, public debates and social policies as sites of similarly important sites of state activity, represents a significant improvement upon earlier binary juxtapositions of political institutions, or social frames on the one hand and technological infrastructures on the other (Chandler 1977, Winner 1977, White 1962). It also affirms that reductionism, regardless if it is the idealistic or materialistic version, is mistaken from the beginning. Clearly, neither side is reducible to its opposite. Instead, on the empirical level, we must learn to see the world as it is. But is the world simply "hybrid", a mixture of the social and the material? This notion and related language are mistaken if they indicate the collapse of two originally separated domains. The anthropologist Descola substitutes the social-nature divide at once with the notion of collectives of humans and non-humans:

> "Once the ancient nature-culture orthogonal grid has been disposed of, a new multi-dimensional anthropological landscape may emerge, in which stone adzes and quarks, cultivated plants and the genome map, hunting rituals and oil production may become intelligible as so many variations within a single set of relations encompassing humans as well as non-humans." (Descola 1996, p. 99)

Similarly, Donna Haraway (1991), Sheila Jasanoff (2004a) and Bruno Latour (1993) argue each in their own way that social theory should overcome the axiom of the "great divide". For Latour this represents an analytically misleading dichotomy between nature and society that is, however, constitutive for the ordering of both modern sciences and politics (Latour 1993). A key modern thinker such as Hobbes bases his Leviathan on a dualist order of knowledge: on the one side the objective "Nature" that is without history, and on the other side the societal sphere that is rife with power struggles over constructed values without any substance (Shaw 2004).

Importantly, the proposals to move beyond the great divide are not merely exercises in speculative philosophy. They are rather supported by three large bodies of empirical work. First, feminist writers have stressed the connected character of the female body where materiality, technology, politics, and identity are inseparably intermingled (Haraway 1991, Butler 1993, Sylvester 1994). Second, researchers who started exploring the practice of natural sciences in laboratories from the 1970s onwards stress the "fabrication" of scientific facts. Their careful observations render substantial differentiation between a pre-existing objective nature at the one hand and agency-given subjects discovering laws of nature at the other hand a fiction (Latour and Woolgar 1979, Knorr Cetina 1981, Knorr Cetina and Mulkay 1983, Pickering 1992, Latour 1987, Pickering 1995, Mol and Law 1994, Aronowitz 1988, Mol 2002).[120] Thirdly, studies about evolving technological systems and infrastructures have shown the profound "socio-technical" nature of technologies. Clearly, their results indicate that reality is not reducible to social interaction. But, against historical materialism, materiality, built environments or technological infrastructures are not determining but highly interactive, constitutive and interwoven with human practices and meaning (Bijker, Hughes and Pinch 1987, Law 1991a, Bjiker and Law 1992, Galison and Hevly 1992, Hughes 1994, Star 1999, Misa, Brey and Feenberg 2003, Jasanoff 2004a, Galison 2006, Dolata and Werle 2007, Ribes and Lee 2010).[121]

Bruno Latour, arguably the most decisive proponent for a new method of exploring "society", advances a symmetrical methodology. This leads him to an understanding that agency is no longer compartmentalized:

> "we have to accept that the continuity of any course of action will rarely consist of human-to-human connections (for which the basic social skills would be enough anyway) or of object-object connections, but will probably zigzag from one to the other. To get the right feel for ANT, it's important to notice that this has nothing to do with a 'reconciliation' of

[120] This understanding diverges from classical treatment of scientific knowledge and expertise in IR. For example, Peter Haas' influential approach relates scientific knowledge in a linear manner to politics, while science functions unambiguously and apolitically in order to realize international cooperation. He only is concerned with the "effective use of consensual knowledge" (Haas 2008, p. 4). Even though Haas refers to Fleck's and Kuhn's writings, he adheres to the idea of unproblematic objective scientific truth as, in principle, strictly separated from politics (Litfin 1994). Cumulative, universal knowledge, thus, is by definition not mixed with powerful political interests. Its great leverage stems from as many (relevant) people as possible sharing their knowledge with other, equally relevant people.

[121] This is not to say that this vast literature does agree on the different emphasis put on the social shaping of technology (e.g. Bijker 1993) or the "material" side (Woolgar 1991, Law 2002). This is itself a matter of controversy. Nevertheless, this body of literature seriously tries to tackle the heterogeneous nature of technologies.

> the famous object/subject dichotomy. To distinguish a priori 'material' and 'social' ties before linking them together again makes about as much sense as to account for the dynamic of a battle by imagining a group of soldiers and officers stark naked with a huge heap of paraphernalia—tanks, rifles, paperwork, uniforms—and then claim that 'of course there exist some (dialectical) relation between the two'. One should retort adamantly 'No!' There exists no relation whatsoever between 'the material' and 'the social world', because it is this very division which is a complete artifact. To reject such a divide is not to 'relate' the heap of naked soldiers 'with' the heap of material stuff: it is to redistribute the whole assemblage from top to bottom and beginning to end. There is no empirical case where the existence of two coherent and homogeneous aggregates, for instance technology 'and' society, could make any sense. ANT is not, I repeat is not, the establishment of some absurd 'symmetry between humans and non-humans'. To be symmetric, for us, simply means not to impose a priori some spurious asymmetry among human intentional action and a material world of causal relations." (Latour 2005, pp. 75-76)

Concepts of performativity in social sciences come close to Latour's understanding. Various post-structuralist writers have employed this notion to capture the theoretical practice of IR as well as de facto international relations (Ashley 1988, Weber 1998, pp. 464ff.). However, these approaches, which mainly draw on Butler or Searle (Butler 1990; Searle 1995), frame agency mainly in terms of linguistic constructions or the enactment of "social fictions". This violates the symmetry principle towards both humans and non-humans. Particularly, the concentration on "agency" conveyed through language, cognition or self-consciousness does not justice to the hybrid character of the contemporary forms of agency.

Against the prevalence of the "IR theory of the social", we can assume ontological categories that comprise of different degrees of agency structured in layers and describe a state of becoming instead of a state of being (Connolly 2011, pp. 21-32, Coole 2013). Often, matter itself *performs* as is suggested in Jane Bennet's *Vibrant Matter*. Things, in this sense, are vital; they possess a "thing-power" (Bennet 2010). Empirically, it can be shown that artifacts, stuff, and materials can align, bond, entangle and connect with other actors and ensembles (Sultana 2012, Coward 2012). The issue of vitality or the "agentic capacities" of human bodies is also at stake in the recent debate about the ways in which bodies are conceptually incorporated in IR studies (Wilcox 2014).

In a similar line, DeLanda suggests choosing emergent phenomena as a main research focus. His macro-approach stresses that, though mechanism of emergence can be distinguished, emergence itself remains unexplainable (DeLanda 2011). So, even with respect to what IR scholars have dubbed as "rump materialism" (Wendt 1999, p. 136) – that is, biophysical entities and atomic and subatomic particles – we must assume differentiated agency and specific vitality (Bakker and Bridge 2006, DeLanda 2011, Barad 2007).

> "The very dynamism of matter (unto 'itself', as it were, without the need for some supplement like culture or history to motor it), its agential and affirmative capacity for change with every doing, is its regenerative un/doing. Matter is always already open, heterogeneous, noncontemporaneous with itself. Matter is always shifting, reconfiguring, re-differentiating itself. Deconstruction is not what Man does (it is not a method), it is what the text does, what matter does, how mattering performs itself. Matter is never settled but is agentive and continually opens itself up to a variety of possible and impossible reconfigurings. Matter is ongoing hauntological transformation. Nature is not mute, and culture the articulate one. Nature writes, scribbles, experiments, calculates, thinks, breathes, and laughs" (Barad 2010, p. 265/FN11).

It is obvious that this ontological understanding runs opposite to critical realist views and also Wendt's quantum account of emergent material agency (see Wendt 2015, pp. 243ff). The former advance a metaphysical approach that tries to improve upon ontological reductionism a la social constructivism. Critical realists in IR advance an integral perspective, stressing "that the material and ideational have to be viewed as a whole" (Patomäki and Wight 2000, p. 235). Their stance treats "nature" as complex activities governed by, at least in principle, clearly discernible natural laws. Consequently, this approach has critical limitations. For one thing, it ultimately comes down to keeping up a dualist ontology (see Lawson 2007). For another, by virtue of foregrounding "natural laws", critical realism privileges a determinist reality, which relegates the material to the natural sciences, and therefore ultimately deemphasizes any agentic capacities of matter (see also Wendt 2015, pp. 280ff.).

Alexander Wendt, on the other hand, proposes a "vitalist sociology" in his brilliant *Quantum mind and social science*. Wendt rejects the critical realist worldview mentioned above, and develops an ontology that tries to capture the human bodies as material and the mind as quantum phenomena.[122] While this book certainly presents the most systematic attempt to reframe IR's ontology and include material agency, it retains a classical way of conceptualizing IR actors. The quantum approach privileges humans and their interactions but still leads to the "three levels" model. Wendt theorizes the state as an organism based on emergent quantum states of individuals (that is, the mind of individual persons) (Wendt 2015, p. 273), but he leaves out the massive technological matter that makes societies and civilizations work beyond and above quantum realities.

This leads us to the question what or who qualifies then as an actor under these fluid conditions. Especially, when technological innovations unfold in a creative way so that controversies erupt and strategies collapse, and stable collectivities are becoming unruly and, at times, matter and ideas conceptually collapse, how can we define agency? Describing the mingled reality of technological innovations in world politics, in other words, means to discard the specific practice of purification that neatly distinguishes the social domain from the material domain. We need a novel set of terms to denote agencies, which do not presuppose a separation between lively subjects and mute objects. This need is acknowledged in law studies, where the proliferation of information technologies that enables the acting at a distance by and through technical agents increasingly leads to the need to legally attribute rights and personhood to artifacts (Koops, Hildebrandt, and Jaquet-Chiffelle 2010). In Chapter 6, it has been that argued that an ethnographical attitude is a crucial methodological component of explorative realism. Capturing the agency of things means first of all describing our own "modern" world, just like "pre-modern" cultures (Latour 2005, Orford 2012). Technological innovations require a research design which ensures that the relations between, and agential power of, *all sorts* of actors are considered without prior assumptions about their alleged ontological or agential differences.

For technological innovations to occur both human and non-human actors play a crucial role. Accordingly, we should not attempt to prescribe what counts as an actor—referring to notions of intentionality only. Explorative realism rather comes down to an

[122] It is not enough space here to develop a more detailed critique of Wendt's analysis and especially how he discusses scientific knowledge and „matters of fact" as part of his own methodological approach.

agnostic view with regard to actorhood. It avoids presupposing a fixed set of actors. It does not a priori exclude 'things'. The term agency, then, denotes a relational effect of both human and non-human actors upon other actors (Callon and Law 1997, Whatmore 2009). Relational effects need to be empirically tested. For that purpose, Latour emphasizes the distinction between the intermediary and the mediator: "Is the element B, whose emergence is triggered by a factor, treated as a mediator, or is it construed as an intermediary for some force simply transported intact through the agency of the 'factor'? We have to be very practical again and as myopic as possible: we are not talking here about grandiose epistemological questions but about vehicles, movements, displacements, and transportation systems" (Latour 2005, p. 105). Exploring agency, in brief, constitutes an empirical research question rather than a conceptual problem.[123]

> "We don't know yet how all those actors are connected, but we can state as the new default position before the study starts that all the actors we are going to deploy might be associated in such a way that they make others do things. This is done not by transporting a force that would remain the same throughout as some sort of faithful intermediary, but by generating transformations manifested by the many unexpected events triggered in the other mediators that follow them along the line. This is what I dubbed the 'principle of irreduction' and such is the philosophical meaning of ANT: a concatenation of mediators does not trace the same connections and does not require the same type of explanations as a retinue of intermediaries transporting a cause (...) [mediators] have to draw connections between entities that are completely different from what before was considered to be a string of social explanations. Those writers state that a factor is an actor in a concatenation of actors instead of a cause followed by a string of intermediaries." (Latour 2005, p. 107)

The acknowledgement of hybrid, heterogeneous, and shifting forms of agency – which are in the following section linked with concepts of process – leads to a perspective on political systems radically different from what is put forward by contract theories and the Cartesian IR framework. Against the presupposition of a society purely made of human-to-human relations, the key assumption consists of a flat ontology which neither

[123] As a result, to expand the ontological parameters of IR so that it includes more than just states, but also non-state actors such as multinational enterprises, NGOs or "polities" (Risse-Kappen 1995, Ferguson and Mansbach 1991), is fine but still amounts to just adding another purely "social" actor to the Cartesian set of established social actors.

privileges humans nor material objects (Latour 2005, Graham 2016c).[124] The reason we should follow those who propose to trace the progress of human societies via the incorporation of an ever-larger number of material objects and artifacts is because this method generates basic insights in how societies remain stable and durable. The stability of relations, and therefore political systems, companies, or states, is possible only through myriads of material mediators (Sturm and Latour 1987).

> "Latour's Leviathan—or political society—is in the first place the result of introducing *non-human* entities that give durability and 'body' to social arrangements. Latour's social contract is thus not a contract between different human individuals, but rather concerns alliances between humans and non-humans. Such entanglements allow us to 'black-box' (or stabilize) some of the hesitations and anxieties that are inevitable in unmediated encounters. By introducing non-humans, the vast, flat expanse of his state of nature can now become populated with elevations constituted by novel entanglements—'macro-actors'—arising out of the entanglement of individuals with things, and the mediation of interaction by symbolic and material entities" (Schouten 2012b, p. 6).

How to study the variegated agency within such stabilized entanglements or "macro-actors"? Following Deleuze and Guatarri (1998), Michel Callon suggests the term "agencements" to conceptually capture the foldings of human-non-human alliances. Agencements indicate the "combination of heterogeneous elements that have been carefully adjusted to one another." These arrangements are "endowed with the capacity of acting in different ways depending on their configuration. This means that there is nothing left outside *agencements*: there is no need for further explanation, because the construction of its meaning is part of an *agencement*." (Callon 2007, pp. 319-320). This ontological understanding implies the necessity to render the various relations among all sorts of actors and their constant reconfigurations visible (Barry 2001).

Criticism has been voiced, in this line, against IR research that treats nuclear weapons as inert, passive and isolated from other inter-human relations. Stressing the agential power of nuclear warheads, Vincent Pouliot inverts the constructivist treatment of technologies: "it is not only people who attach meanings to things; things also attach

[124] Philosophers who strive for an object oriented ontology (OOO) and develop object-oriented methods for social theory, go even further to focus on relations among things that are outside of human reasoning and inaccessible for sensory techniques, that is, almost alien to human thinking (Graham 2016a, c).

meanings to people" (Pouliot 2010, p. 294). Furthermore, Pouliot "seeks to depart from Cartesian dualism and the age-old philosophical distinction between ideas and matter."

> "The materials of practice, which are at once enabling (that out of which practice *X* emerges) and constraining (that without which practice *X* cannot emerge), do not obey conventional ontological distinctions between nature and culture. For one thing, meanings can be as 'material' or non-plastic as matter itself. For another, physical objects are no mere passive repositories for meaning-attachment – often they also attach significations to social relations. Put differently, ideas can be material too; and matter can take on a symbolic life of its own." (Pouliot 2010, p. 295)

Ultimately, Pouliot's view reaffirms a dualism between people and things. For it does not handle the full range of hybrid webs of agency by which nuclear weapons are constituted and maintained. The analytical focus on either the strategic implications of atomic weapons or the "symbolic life" of the bomb within bilateral negotiations, silences various other elements that make nuclear arsenals possible and stable in the first place—the stockpiles, personal, and training, the uranium mines, the radioactive waste facilities, the research institutes, the trade in raw materials, and so on. In order to make this network of local, national and global interconnections traceable, our comprehension of agency needs to include complex agencies across different levels, epistemic fields, and material systems (see Gusterson 2001, Hecht 2010, Ritchie 2010).

In sum, the existing literature suggests a critical role for non-human actors and agential forces within 'social relations' on the one hand, and proposes genuinely relational accounts of agency on the other. Human agency and social activities are hardly ever unmediated. Individual agency and group interactions happen only through and within large ensembles of things, words, symbols, material objects and networks (Whatmore 2002, Aradau 2010, Coole and Forst 2010, Mayer and Acuto 2015).[125] As a consequence, the framing of isolated social actors such as individuals or states, which is implicit to dualist accounts, and conceiving them as self-contained units or systems, is

[125] Further literature in security studies and IR that foregrounds technologies and develops a nuanced understanding of material agency includes Collier and Lakoff (2008), Cooper (2008), Coward (2009), Schouten (2011), Lundborg and Vaughan-Williams (2011), Duffield (2011), and Appel (2012).

untenable for theorizing the transformative effect of technological innovations. The entities called "society", "state", "markets" or the "international system" constitute an array of hybrid and lively webs of humans and non-human agents (Appadurai 1986). Geographic research on resources illustrates how certain biophysical endowments are entangled with specific political institutions and practices of extraction (Bakker and Bridge 2006, Bridge 2008), while research about the emerging information infrastructure reveals the inexorable linkage between new ways of knowing with "large" physical systems and "small" local practices (Bowker, Baker, Millerand, and Ribes 2010). The intricate techno-politics of political and commercial empires through assemblages, webs and imaginaries, which always include and evolved through crucial technical and scientific elements – while modern techno-science itself is partly product of empires (Jasanoff 2006, Potter 2007, Lightman 2008).

In light of these examples, it is important to reiterate that the principle of symmetry does not led to a simple juxtaposition of humans and non-humans; nor the privileging of materials. Numerous studies in geography and STS illustrate that the presumptive notion of sharp socio-technical or static socio-natural divisions is illusionary (Cronon 1996, Castree 2001, Woolgar 1991, Jasanoff 2005). Instead, these authors employ terms such as webs, assemblages, collectives, zones, imaginaries, networks, and associations in order to conceptualize the hybrid combinations and the complex folding of agency and actors that produce social order, political and epistemic entities (Swyngedouw 1999, Barry 2001, Latour 2004b).[126] In term of the recent debates about methodology in IR, the philosophical ontology of these "neo-materialist" approaches falls into Jackson's category of "monism" (see Jackson 2008, 2011). Yet, as Diana Coole points out:

> " (…) if new materialism describes a monist ontology, this does not express a single substance. New materialist becoming is ineluctably multiple and complex; variegated, folded, labyrinthine; and multi-dimensional and multi-scalar. Different levels and entities move with variable speeds and manifest themselves with variable intensity. The point here is that entities, structures, objects all emerge as unstable, indeterminate assemblages that are composed of and folded into manifold smaller

[126] For the fruitful neo-Marxist engagements with heterogeneity and assemblages see Castree (2002), Kirsch (2004), Rudy and Gareau (2005).

> and larger assemblages. At every level, these open systems are reconfigured by their encounters with other provisional constellations, from the tiniest to the most cosmic. The challenge for the social scientist is to trace these densely productive and reversible relationships, without assuming they yield only a chaotic or random flux." (Coole 2013, p.455)

Such is the first move towards the "double-mixed zone". It significantly extends the array of possible actors and agencies that are relevant in international relations by deemphasizing discourse, intentional dimensions and human actors. These heterogeneous assumptions about material agency are illustrated by micro-studies on the material operations of security governance in post-colonial Congo (Schouten 2013) or multi-level probes into the metallurgic fragility of international pipeline politics in Georgia (Barry 2013b) and the novel robotic war experience arising from the unmanned weapon systems (Holmqvist 2013). Similarly, *Making Things International brilliantly shows how globalized assemblages of video filming, garbage, bodies or passports are constitutive for shifting international practices and generating material politics inaccessible to other IR theories (Salter 2015).*

7.2 Emergence and processes of group formation

A shift from substance ontology to process ontology constitutes the second ontological move in order to develop a post-Cartesian framework. It implies to direct conceptual and empirical attention away from assuming what things are, what their quality and properties entail, towards the exploration of becoming, that is, what 'things' and 'groupings' do and how they come into being. With the development of the field of "international political sociology", emergence or becoming have become critical lenses to study world politics (Guzzini 2017). The attention to emerging practices, problems, objects, and actors has, partially, replaced existing process models that were focused on *interaction* between fixed actors and schematic interplay of forces. While the latter understandings of process, such as great powers competition and polarity models (see Buzan 1987), or Marxist dialectics and core-periphery models (Cox 1987) have their merits, the theorizing of technological innovations requires elaborating on the issue of „becoming". This section first discusses the crucial aspects of process ontology and, then, connects this discussion with IR.

Multiple process philosophies have been advanced in Western and Eastern thought traditions; they share some basic commonalities (Rescher 1996, Berthrong 2008). First of all, it is assumed that "one must prioritize processes over things and activities over substances". The ontological categories foreground change and development, while "fixity and persistence" is less important (Rescher 1996, p. 35). Process philosophers such as Alfred N. Whitehead or Gilles Deleuze would agree with the aforementioned post-Cartesian varieties of agency. They share "the desire to develop a new ontological approach, one that goes beyond simplistic divisions or categorizations of the world into subject/object, natural/social, dead/alive, and so on." (Halewood 2005, p. 58, Robinson 2009) In turn, all versions of substance ontology are seen as problematical because they presuppose fixed things. Static assumptions led to logical deficiencies: the properties of things, for example, cannot become intelligible without recourse to the processes of emergence or actual interactions between those things (Rescher 1996). Overcoming substance ontology therefore has several conceptual advantages:

> "Instead of a two-tier reality that combines *things* together with their inevitable coordinated *processes*, [process ontology] settles for a one-tier ontology of process alone—at any rate, at the level of basics. For it sees things not just as the *products* of processes (as one cannot avoid doing) but also as the *manifestations* of processes—as complex bundles of coordinated processes. It replaces the troublesome ontological dualism of *thing* and *activity* with a monism of activities of different and differently organized sorts." (Rescher 1996, p. 49; italics in the original)

In the context of IR, the customary usage of a substance ontology structures research and theorizing in various ways, for the main subject matters are entities such as the "state", which are typically defined in terms of their properties, essences, or attributes and not in terms of the processes that give rise to them (Stripple 2007, Jackson 2009). Substantialist thinking, in other words, has build-in difficulties that prevent the comprehension of change. IR theorists usually construe change by foregrounding the "capacities" of like-units such as in system theories (Kaplan 1960, Waltz 1979, Wendt 1999) or through the idea of unfolding power transitions and resulting hegemonic cycles of war and dominance (Puchala 1994, Kugler and Lemke 1996, Lemke 1997).

Realists see the relevance of technological changes only in thus far as they may lead to shifts in the offense-defense balance. However, this does not imply a shift in the general patterns of activities nor in the ensemble of the pivotal actors, namely the great powers (Jervis 1978, Gilpin 1981, Buzan and Lawson 2015, pp. 240ff.).[127] Change means, in brief, that behavioral patterns of *interaction* among a fixed set of units change. For instance, an unipolar configuration turns into a multipolar configuration (Waltz 1979). The prior existence of these units usually is presupposed instead of a description of their emergence and evolution – not to mention the tracing of new things, practices, or processes.[128]

The literature on economic interdependence and globalization, conversely, interrogates how the movement of knowledge, people, and goods leads to a redefinition of state interests or how it erodes the political authority and regulative power of states versus markets (Hobson 1995, Schirm 2004, Berger 2001, Rudolph 2005). System-theories in IR, despite claims to the contrary, also lack consistent conceptual treatments of agency (Hudson 2007, pp. 10ff.). Conceptually, the issue of change, regardless whether it concerns the consequences of globalization, the Internet or communication technologies, is framed by asking how a fixed set of actors is affected by evolving technologies, economic disturbances, or sorts of secondary actors (see Youngs 1999). So, essential changes as the potential result of technological innovations are less compatible with upholding the premise of the state-system as privileged actor.[129]

When it comes to specifying how technologies lead to changes, the double problem of externalism and techno-determinism (discussed in Chapter 4) comes to the fore again. "The Industrial Revolution", Holsti notes in *Taming the Sovereigns: Institutional Change in International Politics*, "surely a change as momentous as globalization is today, did not reorder major international institutions, except perhaps in the domain of war. In our awe of recent technological and commercial changes, we may forget that this is not the first 'revolution' in world history." Against determinist views, he simply argues that

[127] For a critical discussion of the technological core of the offence-defense balance see Lieber (2000).

[128] But see Ruggie (1993), Newman (1999), Steinberg (2009).

[129] But see Andrew Linklater's point (2010, 2011) that, following process philosophy, societies of states have crucial functions in taming the destructive power modern weapons have over a distance as well as the potential harm caused by reality of global interconnectedness.

technological innovations, after all, do not really change the ontological parameters of international politics (Holsti 2004, pp. 18-19). Obviously, the empirical puzzles discussed in Chapter 2 contradict such claims. Whether technologies are construed as determining forces (Deudney 2000b) or just ignored and downplayed as ‘lower level’ changes ultimately makes no difference.

It is therefore inevitable that focusing on processes leads one to move beyond the substantialist assumptions that underpin the majority of IR theories. For one thing, this meta-theoretical shift subjects the ‘state’ and ‘international institutions’ to a thoroughly empirical historicization. For another, the set of actors and in interactions relevant to IR becomes open-ended. James Rosenau is exemplary in offering a radical challenge to the standard approach. In Rosenau’s terminology, the world is separated in two realms, one of which is “post-national” while the other is still “international”. Especially, in the latter Rosenau renders changes, transformation, and discontinuity intelligible (Rosenau 1990, 2003, see Holsti 1998b, p. 9ff). His approach starkly contrasts with substantialist accounts of inter-action that carry the “illusion of agency”, whereas the agents, who actually operate, are but variables or attributes of entities (Jackson and Nexon 1999, p. 294). Process-based understandings help to investigate historical novelties in terms of actor-configurations and group building instead of suppressing them out of the theoretical need to save a parsimonious theoretical construct. Thereby, process philosophy assumes a variety of genuine and specific agency.

The systematic attempts to apply process thinking to international affairs constitute helpful theoretical exercises (Jackson and Nexon 1999, Albert, Jacobson, and Lapid 2001). In the context of this argument, however, they appear restricted in scope and implications, particularly, because they advance empirical puzzles foregrounding social or intersubjective activities (see Jackson 2009). Linklater has reconstructed Norbert Elias’s idea of a “civilizing process” – that combines “’psychogenetic’ accompaniment to ‘sociogenetic’ or social-structural transformations” (2010, p. 58), to link IR back to the enlightenment project which was fully aware of the transformative and, at times, harmful power of global connections. Buzan and Lawson suggest that the key features of today’s international system resulted form a process of transformation in the 19th century. As such, technological innovations are empirically connected to changes of primary and secondary institutions, great power relations, and core-periphery bias of the international system (Buzan and Lawson 2015). Elsewhere, Mayer (2012) and Allan (2017) suggest theorizing the emergence of major political concerns and governing objects such as “climate change” in the international community. Aside from these exceptions, the predominant substance ontology that underpins the IR framework in general, and the leading theoretical schools in particular, still posits an impediment to the capture of technological innovations.

As technological innovations involve transformational, open-ended processes, the shift to process metaphysics also makes the fixed juxtaposition of agents and structures unsustainable. For the ontological models that are usually employed in IR—positivist, critical realist alike—analogue to the individuals in the “state of nature”, completely miss material mediators. They construe agents such as individuals or states capable of unmediated, merely social inter-actions (e.g. Wendt 1987, Hollis and Smith 1994, Bieler and Morton 2003). In this respect, even more differentiated accounts such as Colin Wight's (2006) suggestion to allow for multiple overlapping layers of structures are not convincing. Wight replaces the simplistic divide between the state and the state-system, although he presupposes a dualist account of interaction focused on social actors. This more complex account of the structure-agency problématique is still indebted to the Cartesian-Kantian line of thought. Post-Cartesian approaches to agency avoid the mind-matter dualism, while rejecting the agent-structures scheme as a matter of principle.

In this sense, an emerging body of work proposes to focus on “international practices” rather than interactions between preconceived entities (Haas 1992, Keck and Sikkink 1999, Pouliot 2008, Bueger and Villumsen 2007). This analytical move opens up the black box ‘state’ considerably more than neoliberal frameworks.[130] If applied to global affairs, the notions of practice fields, actor coalitions, or epistemic communities help to grasp agency beyond the interaction between state-entities (Pouliot and Adler 2011a). The family of practice theories renders the myriads of relationships visible, whereby, in principle, it does not exclude material agency and non-human actors, thus

[130] Neoliberal analysis, in its most consistent version either suggest a threefold model of the world (groups, the state, and the international system) such as Moravcsik (1993) or presuppose a binary model juxtaposing states on the on hand, and market actors on the other hand (Underhill and Stubbs 2006).

providing an option to explore the multiplicity of shifting agencies among and between human and non-human actors over time.

Adler, for example, shows how the "associations" among actors such as political scientists, advisors, politicians, modelers enabled across national borders, political parties and institutional delimitations have established a new policy to control nuclear weapons and to finally reduce their numbers (Adler 1992). However, the conceptual vocabulary and the research agenda involved tends to take recourse to cognitive abilities, professional expertise, and human intentions, while under-representing the material agencies of technologies.[131] The efforts to account for the heterogeneity of agency, in particular concerning different research methods, still have a long way to go in order to realize the goal of symmetry (Allan 2017).

The advances of practice theory are one thing. But tackling the global politics of technological innovations is another. For instance, exploring how emerging technologies such as drones and other robotic weapons become entangled with and translate warfare and power politics (Singer 2009) requires moving beyond existing IR approaches by more radically drawing on process philosophy (Holmqvist 2013). Three aspects arise from the relation between technological innovations and process ontology.

Firstly, processes of technological innovation constitute complex forms of evolutions in which states per se do not play a dominant or leading role (de la Mothe and Paquet 1996).[132] For Schumpeter "states" are not part of the actual process of creative destruction at all. Yet, the "protective strata" such as institutions, interest groups, ideologies, and beliefs play a critical role in his view as they enable entrepreneurs to carry on with their creative destruction (Schumpeter 1943/2003, pp. 131ff.).

Secondly, these processes are powered by creativity. The idea of novelty is crucial. Technological innovation means, both literally and metaphorically, the emergence of

[131] See for instance the collection in Pouliot and Adler (2011b) that is heavily tilts towards a focus in social and human interaction.

[132] This is also where evolutionary economics and the research about "National Innovation System" take different routes (Balzat 2006, p. 32): the latter is mainly focused on national containers, while the former explores rather the dynamic evolution of a diverse set of units such as firms, technologies, products, economic cycles, infrastructures, sectors, national economies, entrepreneurs and so on (Witt 2003, Metcalfe 1998, Mokyr 1990, pp. 273-299, Fagerberg and Verspagen 2009).

something new. They are transformative, partly teleological, but basically without predetermination (Witt 2003, pp. 3-34). At the same time, novelty is not a feature that can be attributed to the advent of an isolated phenomenon, idea, thing, machine, or whatever. Herein lies the crucial difference between the 'invention' and the innovative process. The former may be in the waiting, for instance, in the form of a patent, but might never be picked up (Schumpeter 1947/2008, p. 224).

Thirdly, the full-scale materialization of innovations involves the participation and coordination of all kinds of actors and across what is normally seen as separated "fields" such as the economy, politics, science, and law (Latour 1987, 1988). As such, Joseph Schumpeter and other innovation theorists describe crucial properties of technological innovations (see Fagerberg 2002, Witt 2003, Freeman 2007) that offer, in turn, a rough guidance of what *foundational collectors* should be able to render intelligible. As such, Schumpeter and Latour challenge both IR's preference for staticism and state-centric interactions. Equally, an external or instrumental treatment of technologies inevitably falls short of capturing what is empirically observable.

For Schumpeter the core "problem" of economic development is "'revolutionary' change", a phenomenon that is not captured and often denied by static equilibrium approaches to economics (Schumpeter 1934, p. 63). Technological innovations occur through the "creative response" mainly by entrepreneurs. Schumpeter argues that the transformative character of innovational activities is impossible to foresee or model based on preexisting data:

> "Creative response has at least three essential characteristics. First, from the standpoint of the observer who is in full possession of all relevant facts, it can always be understood ex post; but it can practically never be understood ex ant; that is to say, it cannot be predicted by applying ordinary rules of inference from the pre-existing facts. This is why the 'how' in what has been called above the 'mechanisms' must be investigated in each case. Secondly, creative response shapes the whole course of subsequent events and their 'long-run' outcome. It is not true that both types of responses (adaptive and creative, the author) dominate only what the economist loves to call 'transitions', leaving the ultimate outcome to be determined by the initial data. Creative response changes social and economic situations for good, or, to put it differently, it creates situations from which there is no

bridge to those situations that might have emerged in its absence. This is why creative response is an essential element of the historical process; no deterministic credo avails against this." (Schumpeter 1947, p. 222)

Novelty is not a trivial fact but results from an immanence that may alter the modes of reality in an irreversible way. Antonelli argues that technological innovation arise from "ergodic" processes in which the "initial conditions have no influence on its development and eventual outcomes" (Antonelli 2007, p. 52). This extreme position needs to be calibrated with general insights from process philosophy that distinguishes between processes with stable patterns on the one hand. Certain processes merely reproduce the stability of things, groups, and entities.[133] On the other hand, processes can lead to the emergence of new patterns, things, and processes that are qualitatively different form the prior existing conditions on the other hand (Rescher 1996, pp. 74ff). Technological innovations rather resemble the latter understanding.

If technological innovation means that different agents (not only entrepreneurs) collectively create new conditions, the degree of affected change differs. Schumpeter's generic definition of "recombination" does not suggest a substantial differentiation between different novelties (and their ramifications) as he argues that even a tiny innovative change may have immense and unexpected effects. The modern literature on innovations, however, has typically distinguished between two types: process and product innovations as well as between incremental and radical innovations. While different authors have used this binary vocabulary with different meanings (Garcia and Carlatone

[133] This is because of the reality of constant change. Heraklitos was among the first Greek philosophers who emphasized "panta rei" as a fact about life. But innovations are not the same as saying that you never set your foot twice in the same river (Rescher 1996). In our time, ever since we became aware of the planetary environmental changes that point to the fragility and instability of our "life support systems", the issue of panta rei is ever-present. Immediately, the immense and often unacknowledged achievement of holding our living worlds stable and structured comes to light. For climate change might lead, as many predict, to the occurrence of adaptation limits and even collapse of social structures from villages to civilizations. Global warming, of course, is not the only game in the town. Ongoing socio-technological changes are arguably even more pervasive and far-reaching in its repercussions, in particular since the advent of the first industrial revolution. Despite their different causes and dynamics, these changes stress a crucial issue that is systematically overlooked in many social sciences. The temporary stable patterns and structures of interactions such as tribes, societies, states, cities, families, firms, international organizations, universities, and so on are itself—even without large-scale changes—products of constant up-keeping (Latour 2005). In order to understand their response the internal or external innovations, thus, we need to explore how actors stabilize by for instance routine practices their living environments.

2002),[134] it is safe to say that the former set (process / incremental) is less ambitious and refers to small and continuous improvement steps of an existing system or process. In contrast, product and radical innovations are also often called “disruptive”. Radical innovations require a long-term vision, much more experimentation efforts, research investments, and risk-tolerance, as they largely are steps into the (technological, social, commercial and so on) unknown (Ettlie et al 1984, Dewar and Dutton 1986, Norman and Verganti 2014).

This leads directly to the other important aspect of novelty: technological innovations involve “group formations”. Depending on the magnitude of the innovations this can involve a few or a multitude of other actors and things. The formation of novel groupings or associations is neither limited to a fixed set of actors, nor even to a single ontology and therefore can entail various heterogeneous agencies. For instance, the introduction of infrastructures such as the electricity grid involves processes of group formation that reshuffles pre-existing ensembles of actors, institutions, interests, knowledges and techniques. The entire complex of interlocked processes is what Schumpeter terms “creative destruction” (Schumpeter 2003, Diamond 2006).

We have to notice the crucial difference, here, in terms of importing non-equilibrium notions from economics into IR. The main reason given why entrepreneurs and firms are constantly striving for innovations implies the impossibility to *prescribe* a set of actors. According to Schumpeter’s understanding, economic actors, however small or large in size, and however different in function, are constantly facing a form of competition that functions not primarily on the basis of marginal profits—as traditional conceptions of competition hold—but in terms of extinction.

> “Capitalist reality as distinguished from its textbook picture [resembles] (…) competition for the new commodity, the new technology, the new source of supply, the new type of organization (the largest-scale unit of control for instance)—competition which commands a decisive cost or quality advantage and which strikes not at the margins of the profits and the outputs of the existing firms but at their foundations and their very lives” (Schumpeter 2003, p. 84).

[134] See for instance Hall and Soskice (2001) and (Freeman 1995).

This nervous condition resembles an "ever-present threat"—a state of mind that disciplines the entrepreneur even if he might be the only player in his field or operating under a perfect monopoly (Schumpeter 2003, p. 85). It is telling to compare this with Waltz's (1979, p. 91) quasi-analogy between firms and states. Although both rely on self-help, the latter search for security based on the prime motive of survival, whereas the former strive for innovations to sustain profits. The crucial difference, Waltz suggests,[135] lies in the fact that governments restrict and regulate the competition between companies. Hence, "market economies are hedged about in ways that channel energies *constructively*" (Waltz 1979, p. 91). This line of argument is mutually exclusive with Schumpeter's idea of creative destruction as he suggests that the struggle between firms is not mainly about more or less profits. It is about survival. As a result, Waltz has no difficulties in claiming a fixed set of unitary actors—arguing that the state death rate is low, while Schumpeter's historic account shows the rise and demise of new economic actors, markets, and products as the result of creative destruction.

Another important aspect of the creative destruction lies in the basic blending of institutional domains and practice fields. During their controversial period innovational processes display a seamless web of material objects, social practices, and discursive utterances (Hughes 1983). In other words, when struggles over boundaries prevail no standard set of actors or set of groups does easily apply to innovations.

> "While, after one hundred and fifty years, sociologists are still unclear on what the 'right' social aggregates should be, it is a rather simpler matter to agree that in any controversy about group formation—including of course academic disputes—some items will always be present: groups are made to talk; anti-groups are mapped; new resources are fetched so as to make their boundaries more durable; and professionals with their highly specialized paraphernalia are mobilized." (Latour 2005, p. 31)

Hence, the predominant conceptual notions in IR that presuppose like-units and prescribe certain actors are inappropriate. A static conceptual vocabulary would fail to capture the fact that innovations have revolutionary effects, as innovations tend to destroy prior

[135] There is another illogical argument in Waltz's static account, when he holds that firms were not locked in a permanent struggle for surviving, while at the same time, empirically speaking, he points to the death of firms as compared to states. But, if firms have much higher death rates, why can it be logically derived that their behavior is profit led and risk-taking, as opposed to "defensive" behavior?

existing equilibriums, groupings and relationships. Moreover, the emergence of new things and collectives is a *destructive* process. It comprises the dissolution of existing structures and actors such as the decline of markets, branches as well as the replacement of epistemic boundaries and categories of life and ethics – a process which Sheila Jasanoff calls with respect to advances in biotechnology "ontological surgery" (2011).

The indetermination resulting from this kind of process inevitably leads to "taxonomic complexification" (Rescher 1996, pp. 78-82). As a result, the Cartesian mind-matter divide is destabilized and the idea of "interaction" among a fixed set of actors becomes similarly untenable. In this line, Claudia Aradau highlights Barad's post-Cartesian conceptualization of *intra-active* materialization: "not only are boundaries and objects not pre-given, but matter is an open-ended practice, the historical effect of iterative materializations" (Aradau 2010, p. 6).[136]

> "Matter is generative and agentive not just in the sense of bringing new things into the world, but also in the sense of bringing forth new models (Barad 2007, p. 170). Subject and object, matter and meaning do not exist separately and do not come to inter-act, but are both formed and transformed through inter-action. Intra-action is one of the key terms in Barad's reconceptualization of performativity. It signifies the 'mutual constitution of entangled agencies' (Barad 2007, p. 33) and is opposed to interaction, which assumes pre-existing agencies. Intra-action is an open-ended practice involving dynamic entanglements of humans and non-humans, through which these acquire their specific boundaries and properties." (Aradau 2010, p. 6)

In addition, process philosophy helps us to accommodate to the idea that the same actor may operate or act within different ontologies and thus display different properties and agencies at the same time. This enables us to account for the reality and effects of multiple enrollment and participation of actors in various groupings (cf. Mol 2002, p. 84, Mayer and Schouten 2011). This implies, than, that conflicts, ambiguity, and indetermination are a characteristic feature of technological innovations. As Bijker shows in the case of light bulbs and the bicycle, or McNichol in the case of electrical transmission, it often takes decades for an innovation to mature and to take the temporarily stable shape both materially and discursively (Bijker 1997, McNichol 2006).

[136] For a critique from object-oriented philosophy approach see Graham (2016d).

Therein lays another the reason why binary and dichotomizing frameworks are not suited for studying the collective phase of technological innovations. For the former downplay contingency and fall short of capturing the controversial emergence of technological artifacts and scientific facts through a long phase of fragility that always corresponds with the “coproduction” of the social and epistemological order (Jasanoff 2004a).

The last aspect of technological innovations, which needs to be mentioned here, concerns the instability of tempo-spatial dimensions. This is at the core of evolutionary economics that stresses an “inevitably holistic” perspective because it inquires into “the processes of structural change, rather than the generation of changes in the behaviour of competing entities” (Metcalfe 1998, p. 24). As Schumpeter argues, innovations—and even simple forms of recombination—involve novelties that can break with the preprogrammed and predetermined routines and practices. It could be argued with Schumpeter that the real-world characteristics of innovations are incommensurable with the presumption of linear progress. History, in other words, evolves not gradually, but in jumps, despite economic models that assume static circulation and convergence to the equilibrium (Schumpeter 1934/2008, pp. 57ff). Drawing on non-economic studies of innovation, it becomes clear that the process of innovation entails the emergence of new material-social configurations and, as such, ruptures in basic categories of reality such as temporality, spatiality, subjectivity and objectivity (Kern 2003, Harvey 1989, Galison 2006, Abbott 1990, Harvey 1990).

Taking a *relativistic* understanding seriously renders time and pace unstable. Against the habit of accepting them as constants, we can see these categories as subject matters open to careful empirical research (Fabian 1983, Friedland and Boden 1994, May and Thrift 2001). A growing body of literature explores in this line the planetary “chronopolitics” that is the accelerations of and increasing space-time compression that co-evolve with weapon systems and capitalist globalization (Der Derian 1990; Walker 1993, p. 155, Harvey 1990, Klinke 2013). Others focus on the differing temporalities involved in working discipline and societal organization that had an impact on power projection and European perceptions of Chinese and Indians (Adas 1990, pp. 246ff.). Not to mention the perceived gap between “primitive” peoples whose sense of time is bound to natural cycles: In the nineteenth century, timekeeping was seen as commonplace distinctiveness of the “Western civilization”.

> “Though clocks and watches were often described as object of wonder and amusement for the Africans, European writers considered timekeeping devices as such completely meaningless to their guides and bearers. They were contrivances of a world of ‘railways, steamers, and telegraphs’ which was impossible for the primitive African even to imagine. For explorers (…), the Africans’ inability to comprehend the workings and uses of clocks was yet another manifestation of the chasm in social development that separated Europe from the peoples of the ‘dark continent’” (Adas 1990, p. 245)

Against this background, an explorative realist ontology does shape our research design to the effect that we should employ a toolbox that allows to explore these fundamental discontinuities and (de)stabilizations. To fully capture group formations (and breakups), we have to cope with hybrid agencies, unpredictable creativity and unrestrained ambiguity, which is inherent to technological innovations, and also take notice of possible alterations of basic ontological dimensions and categories of life. Such is the second step to expand the ontological parameters of IR.

7.3 The double-mixed zone: framework for a post-Cartesian onto-politics

The “lightness” of IR that prohibits the exploration of the global politics of technological innovations is no lapse. The deliberate separating out of technologies constituted a major achievement of IR scholars after World War II. As the efforts undertaken by Waltz and Wight exemplify, this was not easily realized (see Chapter 5). This move rejected techno-determinism and shifted the focus to a purely social framing of all subject matters, thus resulting in a framework of IR that was radically Cartesian. Since IR’s neglect of technological innovations is, in turn, intimately connected to the basic notions constitutive of IR, only an alternative framework can shed light on the question of how we can make sense of technological innovations. First and foremost, this task requires ontological expansion.

This chapter has charted how IR might be able to capture technological innovations. Summarizing the discussion, table 4 shows a two-dimensional space representing ontological positions. Plotted along two axes it displays four ontological fields, which can possibly be covered by analytical concepts.

		Process	
		Fixed units/ levels and unit-interactions	Emerging relations and ontologies / group formations
Agency	Technological determinism/social reductionism	**1**	**2**
	Symmetrical notions of agency	**3**	4 “Double-mixed Zone”

TABLE 7.1 A NEW MATRIX OF ONTOLOGICAL POSITIONS. ©AUTHOR

The vertical axis designates foundational collectors that capture agency in technological innovations either from a symmetrical or from a techno-determinist/social reductionist point of view (fields 1 and 3). The foundational collectors grouped at the horizontal axis cover the distance between unit/interaction assumptions and a genuine process-ontology (fields 2 and 4). This conceptual taxonomy, than, corresponds with four different families of foundational collectors.

From the examination above, we can draw tentative conclusions: from a post-Cartesian perspective, the ‘diversity’ of the majority of IR theories, and even attempts to expand ontology, are limited to the upper left area (mostly field 1) of table 7.1. This field represents a stylized version of the Cartesian complex as it produces the meta-theoretical conditions for the core building blocs of IR: the “three levels”, the “like-units”, and “anarchy” as it is purely defined in terms of an rational actor or an inter-subjective problématique. In other words, when we map IR theories onto this ontological parameterization, the general limitations of IR theories become intelligible. The ontological scope of the entire discipline—or at least of the leading schools of thought—

is more restricted than Colin Wight's assessment (2006) would have one believe.[137] Even the most radical (ontological) advancements in the field hardly move out of the upper half of the matrix.

But this matrix also indicates that the room for ontological expansions is enormous. In comparison to field 1, the fields 2, 3, and 4 implicate a more radical adjustment of ontological parameters and lead to by and large undiscovered or uncharted territories. In particular, field 4, which combines a symmetrical approach to agency with process ontology, is most interesting because it extends the ontological scope to the utmost. Yet, this "double-mixed" zone is the most uncommon or, arguably, alien ontological field from the perspective of IR scholarship. It does not just contain a staggering and unfamiliar multiplicity of ontological possibilities that demand novel research designs and methodologies. It is also the best place to begin with articulating a post-Cartesian framework.

The onto-politics of field 4 has two characteristics: first, it entails redefining agency in a symmetrical manner in order to include humans and non-humans alike; second, based on process philosophy, it involves a focus of becoming, that is, emergent relations and processes of group formation. Neither the types of actors nor the set of groupings are prefigured by a priori frames. Both present instead open empirical questions for research and discovery.

> "Although our most common encounter with society is to be overloaded by new elements that are not themselves part of the social repertoire, why do we keep insisting that we should stick to the short list of its accepted members? Such a limitation made sense during the time of modernization. To mark a clean break with the past, it was logical to limit in advance society to a small number of personae gratae. But this doesn't mean that sociology should accept forever to be an object-less discipline, that is, a science without object. Respecting the formatting power of the sociology of the social is one thing, but it's another to restrict oneself to metrology and abandon the discovery of new phenomena. How could we call empirical a discipline that excises out of the data only those that can be packaged into 'social explanations'?" (Latour 2005, p. 234).

[137] For instance, the "great divide" into reflective and rational approaches/ Verstehen and Erklären that—according to the usual reading—fundamentally structures the scope of diversity within IR (Wight 2002, Hollis and Smith 1990) merges into one aspect within the two upper fields.

Only moving towards the double-mixed zone enables us to meaningfully inquire into technological innovations. Epistemologically motivated attempts to reach a closure on the crucial question as to which actors and agencies are deemed relevant to IR are misplaced. So, what is needed to stipulate research and conceptual debates? It is neither genesis-type of stories, nor philosophical speculations such as contract theories. Instead, a precise and detailed ethnography of the "international", that is, solid empirical fieldwork, is required (Coole 2013). This resembles an "explorative ontology or open metaphysics" (Latour 2005, p. 51), meaning that the categories of existence, which we employ in our research, are not fixed, limited and pre-given, but remain accumulating and evolving in an open-ended manner. The actors themselves have a say in these onto-politics while enabling the documentation of agencies and processes that give rise to novel objects, entities, constellations, and collectives is the purpose of this ontology.

8. A world of assemblages

> So wie wir auf dem Wasser schwimmen, schwimmen wir auch in einem Meer von Feuer, einem Sturm von Elektrizität, einem Himmel von Magnetismus, einem Sumpf von Wärme und so weiter. Alles aber unfühlbar. Zum Schluß bleiben überhaupt nur Formeln übrig. (...) "Ja, ja" unterbrach Walter diesen Bericht. "Erst werden aus den vier Elementen einige Dutzend, und zum Schluß schwimmen wir bloß noch auf Beziehungen, auf Vorgängen, auf einem Spülicht von Vorgängen und Formeln, auf irgendetwas, wovon man weder weiß, ob es ein Ding, ein Vorgang, ein Gedankengespenst oder ein Ebengottweißwas ist!" (Musil 1980, pp. 80-85)

Based on the matrix for ontological expansion laid out in Chapter 7, the following two chapters elaborate on a conceptual framework around assemblages and creative destruction in order to make sense of technological innovations in relation to global affairs. The idea of *assemblages* renders an immense empirical landscape and various disciplined bodies of knowledge accessible to IR—including urban and security studies, environmental politics and national law, trade and financial markets, world order and business strategies to name only a few.[138] It is helpful that the term "assemblages" was accepted and applied across many disciplines,[139] signaling its analytical fertility as foundational collector. In addition, as argued in Chapter 3, the concept of assemblages offers a proper mid-range unit of analysis. However, the integration of multiple disciplinary languages, theoretical frames, and methodologies is not a minor task and poses conceptual challenges. The term "assemblage" helps to capture the multifaceted relations between human and non-human agents.

If assemblage captures a snapshot of relations, the concept of "*creative destruction*", which is further developed in Chapter 9, introduces change over time. It theorizes technological innovation as a process entailing the stabilizing and destabilizing of assemblages. For this purpose, I draw on the works at the intersection of political theory, critical security studies, science and technology studies, history, critical

[138] See Friedmann and Wolff (1982), Acuto and Curtis, 2014b.

[139] See Sassen (2006) and Ong and Collier (2008). For two recent examples in IR see Salter (2015) and Acuto and Curtis (2014).

geography and anthropology.[140] This conceptualization of technological innovations follows the principle of symmetry and aims at proposing a distinct "post-international"[141] perspective.

The chapter starts outlining the central importance of technologies for understanding assemblages. I assume assemblages could neither exist, nor have a stable shape, without all kinds of artifacts—alongside with words, images, and concepts. Assemblages are furthermore understood as a performative process of group formation or evolving webs of relations (Callon and Latour 1981). This understanding directs the research concern away from static notions such as structures, units, levels, institutions, or systems (8.1). Instead, the notion of assemblages suggests focusing on heterogeneous agency, the power of acting in concert, and the role of non-coercive authority (8.2). Classifications that systematize the world of assemblages discussed but have to remain open-ended (8.3). Chapter 9 extends, then, this framework proposing three models of creative destruction: assembling, reassembling, and disassembling.

8.1 Emergence and stabilization

Assemblage is the analytical concept that appropriately denotes a world comprising multiple and clustered relations between humans and non-humans.[142] The meaning of assemblages needs further clarification. How does the concept of assemblages replace dualist assumptions and logocentric vocabulary contained in the notion of "socio-technical" systems and similar notions? The term assemblage is a *foundational collector*

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[140] Including among others Murdoch (1989), Swyngedouw (1999), Barry (2001), Aradau (2010), Schouten (2013), Elden (2007), de Laet and Mol (2000), Law and Callon (1989), Castree (2002), Latour (1987), Law (1991a), Legg (2011), DeLanda (2006), Mayer (2012a), Farías and Bender (2010), Bueger and Villumsen (2007), Bellanova and Duez (2012).

[141] The perspective developed here differs from neo-medievalist portrays of world politics (Friedrichs 2001); from frameworks that replace the "international" with numerous "polities" (Ferguson and Mansbach 1996); and also from approaches to global governance (Dingwerth and Pattberg 2006). While other scholars previously have employed the term "assemblages", my use diverges from Saskia Sassen's (2000, 2006) temporal-spatial focus as well as from the "global security assemblages", which Rita Abrahamsen and Michael C. Williams advance (2009); since the latter works fall short of fully developing a symmetrical analysis.

[142] In the following I use associations, ensembles, assemblages, actor-networks, and collectives as synonyms because all these terms contain a common analytic meaning and are employed in different bodies of research I drawn on.

that is post-Cartesian in a dual sense. First, it does not refer to pre-given categories such as sovereign states, society or the international system. As discussed in Chapter 7, and as Thomas Hughes famously has put it, the building blocks of reality are "seamless webs". Therefore, theoretical distinctions between fields, structures, domains, or levels make little sense (Hughes 1986, 1991), and the convenience with which one imposes *a priori* differences without due recourse to empirical observations and factual plausibility capsizes. Assemblages can refer to objects reaching from planetary size to tiniest things without the need to deductively distinguish between different levels such as "local" and "global" or "micro" and "macro". In terms of size and diversity, assemblages might entail everything from an electron to a car to a transnational supply chain; from a local criminal network to a full-fledged techno-civilization that spans beyond Mars.

Second, this foundational collector signifies collectives of human and non-human agents; they are able to embody the material and heterogeneous aspects of technological innovations, which theories of the social usually purify. Several strands of theory help to further develop the thingness of human worlds that is seen through the lens of associations. Political philosopher Hannah Arendt, for instance, has emphasized the central importance of things and technologies to human existence (Arendt 1989). Against the backdrop of the ever fluid and circular processes in the natural world that affects humanity as a species, the conditions of possibility for human societies to exists, and similarly for ownership and markets, is bound to durable artifacts. Artifacts including technological infrastructures increasingly enable the flows in the global economy and in daily life as the sine qua non for sociality and freedom. Arendt has also critically scrutinized the way in which machines turned work into labor and were significant for the rise of the "consumer society" (Arendt 1989, pp. 124-139). In this sense, technologies make the social durable, a theme we will return to later.

Assemblages, in addition, are concerned with the relational character of human life. Biologist Gregory Bateson has explored humans as "extra-regulators". What unites humans with few other species is the ability to regulate and design the climate, the geography, the fauna and flora in their surroundings (Bateson 1973). This renders human group formations by definition closely intertwined with artificial environments in a way that blurs the line between allegedly social- and non-social relations. It constitutes a biological actuality.[143] It is the primordial condition of being human as Peter Sloterdijk points out. Building on Heidegger's arguments, he emphasizes the beginning of human life as an "ecstatic entwinement of the subject in the shared interior" (of the female womb). The existential intermingling of human life, as Sloterdijk's "spherology" stresses, spurs a psycho-metaphysical drive that renders human history—on the individual and the species level—one of a global expansion of technological self-domestication (Sloterdijk 1999, 2001). Jongen summarizes:

> "Held out into the monstrous, humans can only survive and thrive if they create for themselves a 'technologically enclosed external uterus', (…) or in other words if they move into a 'human greenhouse' fabricated through material and symbolic 'anthropotechnologies', in which they nurture, protect and immunise themselves against the unlivable outside. The clearing that emerges as the world comes into being is created by technology. This is the crucial point: it is the result of a human 'technology of self-domestication'" (2001, p. 197)." (Jongen 2011, p. 206)

From another angle, Bruno Latour suggests a corresponding reading human macro-history: human-nonhuman actor-networks expanding across the planet in phases (Latour 1999a, pp. 176-215, see also Mumford 1966). This is a mythical narration of course. But unlike Sloterdijk's psycho-drama of co-existence, where the human tragedy of never regaining original unity—wholeness, or "hominess", to use Sloterdijk's phrase—takes center stage, Latour describes human progress as the stepwise "socialization" of additional things into human collectives (Latour 1999a, p. 198). From including more and more non-human actors spring layers that are neither hierarchically structured nor ordered according to a teleological sequence. In the same line, Manual DeLanda (2000) suggests that the world is composed of myriads of assemblages, which he describes as "irreducible and decomposable" wholes. Every assemblage, despite its possible resemblances with others, has always a specific individual history (DeLanda 2011, p. 185). In short, assemblages can interact and become interlocked into layered webs of complex activities. But how do they emerge?

[143] When IR scholars came to acknowledge economic interdependence (Keohane and Nye 1977) and human-environmental interconnectedness (Strange 1999, Linklater 2009) did not fully capturing the long history of structural interdependence in this sense.

DeLanda compares the homology of emerging thunderstorms, intelligence, language, and complex social organizations. Here, “emergence” is understood as

> “a contingent accumulation of layers or strata that may differ in complexity but that coexist and interact with each other in no particular order: a biological entity may interact with a sub-atomic one, as when neurons manipulate concentrations of metallic ions, or a psychological entity interact with a chemical one, as when subjective experience is modified by a drug.” (DeLanda 2011, p. 6)

DeLanda points out the crucial differences that distinguish assemblages from organic totalities, as conceived by Hegel and others:

> “While those favouring the interiority of relations tend to use organisms as their prime example, Deleuze gravitates towards other kinds of biological illustrations, such as the symbiosis of plants and pollinating insects. In this case we have relations of exteriority between self-subsistent components such as the wasp and the orchid; relations which may become obligatory in the mores of coevolution. This illustrates another difference between assemblages and totalities. A seamless whole is inconceivable except as a synthesis of these very parts, that is, the linkages between its components form *logically necessary* relations which make the whole what it is. But in an assemblage these relations may be only *contingently obligatory.* While logically necessary relations may be investigated by thought alone, contingently obligatory ones involve a consideration of empirical questions, such as the coevolutionary history of two species.” (DeLanda 2006, p. 11)

In short, insights from philosophy, ecology, and STS tell us that technologies are indispensable for the stability, historical progress and character of “human” collectives. We must expect, in the light of the symmetry principle, that technological innovations never occur external to “society” and that they will automatically entail and embody human intentions, norms, institutions and so forth. As a consequence, all collectives—be it in the form of states, firms, churches, or criminal networks—are “hybrids” of different forms and sizes.

Given their generic heterogeneity, another difficult question arises: what holds assemblages together? Assemblages are constitutive for the world and our experience, yet are chronically unstable and decaying. The law of atrophy appears to apply. Because stability needs to be explained, we cannot simply assume some form of hidden power forces or structures that cause the stable state of an assemblage. According to the methodology of explorative realism, stability is an empirical question and the actor-network approach points out various mechanisms for inquiry. For now, it suffices to refer to the role of performativity. Assemblages can be decomposed into a temporarily stable set of interrelated practices and agentic programs. Acts or practices mean locally routinized activities involving intentions and emotions, material elements, discursive representations, and tacit knowledge (Reckwitz 2005, Adler and Pouliot 2011a, p. 18). In brief, the stability of assemblages depends on performance.

When practices and circulation stop, connections break down and an assemblage may immediately disassemble. "Because there exists no society to begin with, no reservoir of ties, no big reassuring pot of glue to keep all those groups together (…) the object of a performative definition vanishes when it is no longer performed" (Latour 2005, p. 37). For instance, a house that was assembled from stone, wood, glass, steel and so on. Without maintaining, heating, securing, repairing, and simply living, every house falls apart soon to be no longer recognized. As performance is the glue without which human realities would fall apart, we can speak about assemblages primarily in a performative sense. Yet, against the concentration on "social agency" anchored in self-consciousness, and against the resulting inadequate "sociology of the social" that is prevalent in IR, I would assume—in line with process philosophy—that matter also performs. In the light of the above, my approach departs from merely considering "social" performances (Whitehead 1979, Rescher 1996; see Chapter 7). Concerning assemblages, technological agencies are part of performativity.

A complementary explanation for stable relations among heterogeneous actors refers to the circulation of "immutable mobiles". Actors within a network are connected, among other things, through the constant movement of immutable mobiles such as devices, vehicles, standards, and "collecting statements" (Latour 2005, p. 196). It needs to be noted that immutable mobiles do not deterministically prescribe practices. They rather make actors "do something", largely, helping an assemblage to march in unified fashion because they function as "metrological" instruments (Latour 1987, p. 251). They support the standardization and the normalization of practices and subjects across different localities and spaces (Oakeshott 1975). The circulation of immutable mobiles cuts across all "levels of analysis" and "domains" as they keep practices and routines stable. Just imagine how we would know the time without coordinated global time zones and billions of clocks? How would one know distances, spatial location, and weights without standard measurement units, cable signals, laser devices, and satellite position systems? Or, how could economic activities, state policies and personal lives be enacted without standardized sets of statistical measurements and respective data? How would we imagine political communities without statistical means or common memes of reference?

8.2 Agency

What kind of agency is relevant for understanding assemblages? How does technology feature as actor accordingly? Drawing on ANT in particular, my approach to agency comes down to a notion of relational effects (Powell 2007, p. 318).[144] Consequently, an actor is defined in terms of whether he/she/it is able to divert other actors from their intentions, identity, or activities. As should be obvious from the discussions above, such an approach to agency does not refer to Langdon Winner's famous *Brooklyn Battery Bridge* (Winner 1986)[145] – architectural designs that presumably were a congealment of a racial ideology; nor does agency necessarily involve human intentionality.

A thought experiment will clarify why concepts that privilege self-conscious actors fail to capture agencies within performance of assemblages. Imagine a large iron bridge that is part of a high-speed train connection between two metropolises. After a severe flooding, the iron structure of the bridge displays tiny fissures, which make the railway company stop traffic. All of a sudden, a material component that was reliable for decades requires attention. Engineers have to be sent out to open up the "black box" that the bridge has been since its construction was completed. While engineers figure out the concrete damage and assess the instability of the iron frame, the railway management redirects bullet trains, rendering the normal schedule obsolete. Passengers have to be

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[144] In contrast to what its critics postulate, ANT is not a constructivist approach to "science" and "nature". Instead, it constitutes a pragmatic research attitude and offers a methodological toolbox to inquire into how humans and things are entangled by presupposing as few assumptions about actorness as possible (Law and Hassard 1999). See also Chapter 7.

[145] Winner's influential example for determinism, besides being factually incorrect (Joerges 1999), does not capture what is here understood as material agency.

informed, bus transports have to be organized, and so on. It may take weeks or months until the bridge is repaired, that is, repacked into an unproblematic functioning black box. Only when this is accomplished will the entire assemblage of rail traffic enter a stable state. This example illustrates aspects of non-human agency. Technologies are not only essential parts of assemblages; they also possess the potential to become actors in their own right. Following the STS literature, we can distinguish among three forms of "technological agency".

a) *Technological agency consists of complex cascades of actors.* Computer systems that are undertaking complex economic activities constitute the quintessential example for the complex forms of agency that signify our contemporary world. The consequences of massively incorporating artifacts are illustrated by the widely anticipated "millennium bug"—an alleged incapability of software to switch dates to the next century. An estimated $200bn to $858bn was spent worldwide to prevent the expected disruption of global financial systems, electricity supplies, nuclear weapon facilities, and air traffic control. Yet to many observers it was not clear whether these huge expenses were justified at all: "The bug panic [is] a symptom of our immaturity about technology generally. Businesses and the public are increasingly dependent on computers, but still understand little." (Beckett 2000) As the real costs of the bug can never be clearly ascertained, it remains unknown whether there were serious threats at all.[146] The crucial point is that the "millennium bug" implies a profoundly complex agency that may disrupt markets and societal systems.

Activities that social science usually conceptualizes purely as human agency are, in fact, irreversibly mediated by a mix of technical devices, algorithms and fiber cables; alongside with images, symbols, and utterances (Pinch and Swedberg 2008). For Latour, it is the myriad of material objects "through which inertia, durability, asymmetry, extension, domination is produced" (Latour 2005, p. 86). Agency is empirically located in "a thoroughly artificial reality generated by humans and their cultural technologies. This artificial reality", as Marc Jongen argues, "has no ground onto which one might leap" (Jongen 2011, p. 214). It is because of this degree of complexity, that Michel

[146] Others stress that the Y2K problem really existed and has been averted (Schofield 2000).

Callon and Donald MacKenzie highlight the practical difficulties of *attributing* agency. Understanding economic actors in financial markets as "sociotechnical combinations", they note that actors are lacking fixed attributes or characteristics and should be viewed as the effect of "agencements". Agency cannot simply get attributed to unitary human actors but belongs to complex hybrid ensembles that act in concert. This notion, then, directs our analytical focus away form "agential peaks (…) not just towards things but towards less high-status human beings." (MacKenzie 2009, pp. 21-22, Callon 2007)

b) *In a process of translations technological agency can shift goals, identities, and activities of other actors.* The replacement of actors' attributes and properties has various manifestations. Chapter 2 has mentioned how the nuclear bomb led to a variety of translations. Ultimately, these controversies led to a replacement previous aims of national security and defense strategy. The decision makers at both sides were struggling to prevent high-speed weapon systems from annihilating the room for reasonable decision making at all. The large-scale technological associations that were assembled for the "management" of the bomb ultimately transcended the bifurcated Cold-War imaginations. Experts, policy makers and the public on both sides acknowledged that the super powers share one earth with fragile ecological systems (Gavin 2012). Translation, obviously, constitutes a highly non-deterministic process. The ambiguity of technological assemblages always offers multiple options of replacing properties, goals, and interests by differently relating actors within and across actor-networks (see Tenner 2004).

Another variety of translation involves changes in the composition of large technological assemblages that lead to malfunctions of certain elements. Here, the creativity of innovators (human actors) plays a central role. For instance, as shipbuilders increasingly constructed large ships by steal and with steam engines replacing sails, the traditional magnetic compass, which had provided reliable orientation to navigating for centuries, ceased to function due to electromagnetic fields. The solution came in form of the gyrocompass that was invented just before World War One. Yet, as Thomas Hughes points out, existing actors and institutions were not simply applying inventions such as the gyrocompass. Inventor-entrepreneurs have seldom found "an established manufacturing firm willing to abandon a line of products in which it had heavily invested skill, knowledge, and capital in order to develop a new innovation unrelated to its investment." Typically, inventor-entrepreneurs do only succeed by translating institutions, laws, norms, or mind-sets. They invent "not only a device but an institution for manufacturing and marketing as well." (Hughes 1991, p. 14, Todd 2001) While Schumpeter (1947) refers to successful entrepreneurs who master this situation with their "creative response", Goddard (2009) shows that political entrepreneurs display similar abilities.

A final case involves material agency that initially was external to an assemblage but may interrupt the flow of circulation and, hence, has to be considered and "socialized" in some way. A recent exemplification for this source of instability is the 2010 eruption of the Eyjafjallajökull volcano in Iceland. The civil aviation authorities closed north European airports, stopping most transatlantic and inter-European flights because the navigation systems and aircraft engines were thought to be unreliable. When the volcanic ash relentlessly kept diffusing into the northern hemisphere, air traffic was shut down for weeks. In response, different actors tried to integrate the ash particles as new actors in order to facilitate the restart of aircraft circulation. This was done by modeling and measuring the new actor, making it visible and intelligible by means of computer and navigation systems, and by testing the engines' ability to withstand the new member of the collective. The institutional ensemble of international and national authorities in charge of air traffic control meanwhile issued new standards and benchmarks in order to coordinate traffic over Europe. All this involved intense negotiations in a seamless web of bureaucracies, turbine engines, passengers, computer simulations, economic concerns, and last but not least myriads of ash particles (see Adey, Anderson, and Guerrero 2011). So, several collectives underwent a translation process, as described above, in order to accommodate an "irritating" new member.

c) *Artifacts and systems are ambiguous actors, which can provoke controversies and instability.* Technology does not per se possess agency. Contrarily, technologies often are "black-boxed"—that is, they are taken for granted, functioning as mere intermediaries. When bridges or computer programs, for example, work smoothly they are black boxes co-constitutive of passengers, railway companies, and banking systems. These "intermediaries" do not divert actors from their normal course of action. Vice versa, actors that make a difference during translations behave unexpectedly as they turn from an intermediary into a mediator (Latour 2005). When black boxes are reopened, technologies stir public controversies. Even a tiny actant that does not smoothly circulate or perform can disrupt the practices of all other actors in a network; the taken-for-granted mode of life breaks down. Compare, for instance, the accident of the Space Shuttle Challenger (Vaughan 1996) with a scenario in which regional electricity supply systems break down. Depending on the size of an assemblage this can lead to disasters of different magnitudes. Destabilizing technologies are able to disturb all other elements and relations within an assemblage and, therefore, divert human actors from their usual practices.

Even the largest assemblages remain fragile and require constant efforts of upkeeping and stabilizing. The reason these efforts are difficult is also because the same actors are often enrolled in different associations at the same time. Thus, overlapping, inter-locked, or possibly competing assemblages push and pull upon the same actors. Assemblages can never really escape ambiguity. In an assemblage, due to its flat ontology, the agency of its elements is never irreversibly suppressed. The consensus and alliances that enable a certain network "can be contested at any moment" (Callon 1986, p. 15). As a result, disruptions in the chain of connections may appear instantly, stopping the circulation of artifacts and the practices by which actors perform in concert. This constitutes a typical characteristic of technological innovations.

It should have become clear by now that assemblages are conceptually rather distinct from totalizing notions such as "structures" and "systems"—auto-poetic or otherwise. They do not resemble static container-like concepts of social groupings. Their spatial boundaries are penetrable and their elements and agential programs are not strictly separated from the environment. The three aspects of material agency—heterogeneous complexes of agency, translations and ambiguity—become meaningfully operational to the extent to which two central notions related to assemblages are considered: power and authority.

8.3 Power and authority

In the context of assemblages, the concept of power does not refer to a domination of the thinking or the behavior of other actors as proposed by thinkers such as Machiavelli, Hobbes, Rousseau, Weber or Dahl. For one, geometrical assumptions of *unmediated* power relations do not stand empirical scrutiny. It is progressively unreasonable to derive definitions of power from a laboratory situation that allows only for the interaction of two rationally calculating minds while everything else is kept constant.[147] This sort of highly artificial condition, though widespread in IR and IPE theories, has no resemblance to the nitty-gritty of a world full of technological heterogeneity.[148] For another, it is important to avoid the conflation of power, influence, and violence. While the frequent occurrence of forms of violence is a matter of fact, conceptually speaking, this often implies the *absence* of power. Writes Arendt:

> "where commands are no longer obeyed, the means of violence are of no use; and the question of this obedience is not decided by the command-obedience relation but by opinion, and, of course, by the number of those who share it. Everything depends on the power behind violence. The sudden dramatic breakdown of power that ushers in revolutions reveals in a flash how civil obedience—to laws, to rulers, to institutions—is but the outward manifestation of support and consent." (Arendt 1969, p. 49)

Taking seriously a world of assemblages, one cannot conceptually foreground command, coercion, and control. Instead, the understanding of power most adequate for studying the politics of technological innovations amounts to a "collective momentum". Hannah Arendt and Michel Foucault propose respective conceptual approaches (Allen 2002). According to Arendt's differentiation between the notions of power, violence, strength, and authority, power means a "unified marching". It constitutes a collective activity (Arendt 1969, pp. 44-45, 50ff). For Arendt, power does not belong to a single actor but "springs up whenever people act together and act in concert" (Arendt 1969, pp. 52). As for the conditions for "collective action" there is a parallel in the thought of Arendt and Foucault. Arendt (1989) affirms power as a positive expression linked to the availability of a public sphere while Foucault (1983) understands the discursive embeddedness of actors as constitutive of their subjectivity and agency. Against coercion-obedience models of power, Foucault's concept of governmentality finds power located in quotidian

[147] Actors and agency are always enmeshed and constituted by assemblages. Unidirectional leverage or purely bilateral power constellations by and large are absent in real world environments.

[148] Even more integrative frameworks of power (see Barnett and Duvall 2005) must be rejected on empirical grounds for they fail to account for the meditative role of technologies.

practices—including the resistance to them (Burchell, Gordon, and Miller 1991, Allen 2002). So, while for Arendt and Foucault "power" refers to coordinated practices within stable collectives, I assume following STS that any conceivable "concert" naturally includes non-human actors such as technological artifacts. This results in the abstract definition of power which resides with ensembles of human and non-human actors who act in concert.[149]

"Acting in concert" has a substantial meaning. The concerted practices that constitute assemblages are fabricating dimensions of reality including space and time. The latter, in other words, can be understood as the effects of power operating within stabilized assemblages. In other words, power is "productive" (see Barnett and Duvall 2005). The global standardization of time illustrates the productive dimensions of power. Against the assumption that time and space are stable, geographers and historians trace how both have been constructed and need to be maintained—though they are not purely social constructions (Harvey 1990, Kern 2003, Thrift 2002) Over centuries, only differing local times existed which were not comparable. Traveling was difficult for no single time standard existed. Especially, navigators on ships had greatest difficulties in determining their location as they needed precision time facing the so-called impenetrable "longitude problem". As clocks were not working exactly enough, ships used to carry several clocks. Only when clockmaker John Harrison's famous timepieces won him the Longitude Prize of the British Royal Society—not after personally appealing to King George III—reliable clocks stabilized and simplified naval navigation enormously (Taylor and Wolfendale 2007, Wilford 1995).[150] It was in the late nineteenth century that a single standard time was—driven by expanding railway systems and engineering entrepreneurs—agreed upon both within nations and worldwide (Stengers 1997, Bartky 2007).

The crucial point here is that we simply can't treat time and space as *constants*. Space and time are neither fixed external realities of life nor globally given constants (Latour 1987, Sack 1986). Instead, the existence and standardization of time and space

[149] Subsequently, coercive types of power have only limited relevance in an actual world of assemblages.

[150] Although contemporary clocks work several magnitudes more precisely than their precursors—relying on highly expensive and complex combinations of atomic clocks—the satellite navigation systems still face the same challenge of stabilizing the time regime on which our technological assemblages rely (Debrunner 2011, Galison 2006).

relies on complicated networks that require immense maintenance costs; another reminder how indispensable artificial objects are for the durability of modern civilization (Law 2004, Latour 2005, Crang and Thrift 2000). Here comes a crucial difference with the notion of "time-space compression" (Buzan Lawson 2015, pp. 67ff). Whereas the latter claim indicates the mere collapse of space and a simple reduction of distance, the idea of agencements or assemblages implies that we study more closely the intricate ways in distance is "compressed" – the operations of "power" that overcome distances and act upon remote parts of an assemblage. Here, the role of "immutable mobiles", maps, chronometers, forms, or mathematical calculations, as they circulate and connect localities across networks is crucial. Because the "results of building, extending and keeping up these networks is to act at a distance, they do things in the centres that sometimes make it possible to dominate spatially as well as chronically the periphery." (Latour 1987, p. 232, Porter 2013) In sum, power here means acting in concert to the effect that, among other things, space and time are synchronized and stabilized. From that springs a hypothesis, which stretches the meaning of "productive power" beyond subjectivity (see Barnett and Duvall 2005): different assemblages (or combinations of assemblages) may produce *relative different life worlds* that envelope partly incommensurable modi of existence.

"Authority" is the other notion critical for understanding the emergence of assemblages. Different from power, the term authority signifies the ability of actors—human and non-human alike—to assemble and interconnect (with) other actors. The endowment with authority does not stem from threatening others with coercive means or using violence, although authority is unevenly distributed during processes translations and actors come to occupy central positions. For instance, it is unconceivable that a cell phone treats you violently. Nonetheless, myriads of smart phones and other digital communication gadgets make billions of users worldwide fundamentally reorganize their working environments, shaping their communication manners and transforming their love lives (Castells 1996, 1997). In addition, the application of information technologies increasingly transforms war theaters, defense parameters and the mechanisms of power (Castells 2008, Farwell and Rohozinski 2011, Singh 2013). Or take the car as another archetypical non-violent authority. For decades, the automobile assembles more and more actors, inter-relating among many things fuel prices, oil extraction, street size, traffic systems, industrial pride, urban planning, labor policies, billions of tons of concrete, imaginations of male-hood, and racing sports (Paterson 2007, Volti 2008).

Extending or reconfiguring an assemblage requires authority. This, first of all, involves negotiating, indeed a lot of negotiations, in order to achieve shared conventions and a consensus. Authority is the ability of actors such as for example inventors, technical artifacts, criminals, entrepreneurs, genes, scientists, states-man, and so on, to convince other actors without violence to assemble in the first place. The use of violence, in contrast, rather equals disassembling a collective into its pieces—literally or figuratively—or at least undermining efforts to stabilize a collective.[151]

While applying violent force often supported acts of disassembling, the case of US military engagement in Iraq and Afghanistan sadly drives home the crucial point that violence or coercion must not be confused with power. Advanced weaponry and high-tech soldiers have conquered both countries, tearing apart preexisting assemblages, but US forces still strive to stabilize the kind of assemblages they wished to have in place in these countries. CIA and DoD drones enjoy almost unrestricted access hunting down "terrorist targets" in order to help reduce US death tolls and the number of extra-legal detainees. But they have also caused thousands of civilian casualties (Junod 2012). At the same time, Afghanistan had been turned into the most fortified country in the world with thousands of "foreign" and "domestic" military installations. Yet, "even with 4,200 bases set up to secure the country, along with close to 80,000 troops from the most technologically sophisticated and well-funded military on the planet (with assistance from 40,000 personnel from other powerful armies) and an allied indigenous force of around 350,000 soldiers and police," notes Nick Turse, the war remains unfinished. One important reason for infinite war is that the enormous build up of military infrastructures does not provide sufficient authority to stabilize the assemblage of the Afghan nation.[152]

[151] In this line, Arendt (1969, p. 56) remarks suit well: "to speak of violent power is actually redundant. Violence can destroy power: it is utterly incapable of creating it."

[152] Not to mention the prewar plans of US companies and politicians that foresaw Afghan oil-pipelines. Not only has military might "been unable to decisively defeat a rag-tag, minority insurgency of limited popularity" (Turse 2012); dotting the landscape with military installations has not brought peace in any tangible sense.

The groundwork of stabilizing instead requires collective negotiations—based on the authority to assemble large numbers of human actors and material objects inside and outside of Afghanistan—as the Carnegie Foundation reminds hawkish pundits:

> "instead of a simple 'surge,' there needs to be a much clearer focus on bringing security to Afghans' daily lives. Only once this is achieved will Afghanistan's government have real reservoirs of legitimacy. (…) the United States should support systemic reforms, first through the development of an effective executive office to support the Afghan president. Counternarcotics policies in Afghanistan must take account of domestic socioeconomic complexities, and be based on long-term development projects that increase the returns from cultivating different crops. Serious thought needs to be given to encouraging more Muslim states to contribute personnel to support the promotion of human security and development in Afghanistan" (Maley 2008, pp. 1ff).

At this point, deepening our understanding of authority benefits form studies on international regimes and global governance.[153] Accordingly, authority resembles "a patchwork that does not lend itself to simple generalizations. It is negotiated between authorities and communities, multiple in forms, and continuously contested. Most authority in the world today likely still originates at the national level, but this is possibly changing as globalization progresses." (Lake 2010, p. 600, Djelic and Sahlin-Andersson 2006) For example, the governance of the Internet and the politics of communication technologies are shaped by various actors and agencies without a clear hierarchy (Mueller 2010, Mayer-Schönberger and Lazer 2007). Though censorship and access control abound (Deibert et al. 2010), state agencies cannot dominate the highly heterogeneous set of governance activities. So, in principle, we cannot presuppose any privileged authority such as for instance sovereign national states. As David Lake states: "all authority is negotiated" (Lake 2010, p. 598).

> "(…) the emergence and workings of such hybrid forms of organization and steering remain under-studied. In particular, we have only just started to make sense of the myriad of transnational networks comprising governments, business and civil society groups currently shaping the emergent socio-political problems and opportunities." (Flyverbom

[153] See for Dingwerth and Pattberg (2006), Held and McGrew (2002), Hall and Biersteker (2002), Grande and Pauly (2005). However, only a few authors chose technological innovations as a central research concern (see Sandholtz 1993).

2011, p. ix)

In general, I agree that the heterogeneity of authority dethrones states as the primary crystallization site of the "political" (see Stripple 2006, Avant et al. 2010). However, there is a crucial conceptual difference. Though approaches to global governance evolve to a certain extent in parallel to the concept of assembling, these frameworks suffer from IR's lightness. Authority, for my purpose, does not denote, as Lake argues, a "*social* contract in which a governor provides a political order of value to a community in exchange for compliance by the governed with the rules necessary to produce that order." (Lake 2010, p. 587; italics by author)[154] Authority, instead, signifies the *performative ability of actors to bring about assemblages by means connecting and enrolling human and non-human actors*.[155] Authority is linked to human and non-human actors possessing a non-coercive power-generating agency. It belongs, for example, to Schumpeter's innovating entrepreneur-heroes, to Adler's (1992) "epistemic communities" and to Chandler's organizational managers as much as it resides in Galison's, Latour's, and Hughes's engineers and scientists, who are weaving seamless webs (cf. also Goddard 2009). Varying degrees of authority are similarly invested in networks which become political actors on a global scenery (Sassen 2004, Grewal 2008, Kahler 2009). And no less may, as pointed out by ANT, artifacts and things command the capability of collecting actors to construct (or reshape) an assemblage through establishing solid connections between human and non-human actors (Latour 2005).[156]

In conclusion, assemblages require a fresh conceptual vocabulary of power and authority. Power here is defined as *coordinated collective performance having productive*

[154] The same purely „social“ approach is inherent to the related "network power" definition offered by Castells (2011).

[155] Although I build on Arendt's useful conceptual clarification of the terminological field of "power", this understanding differs from Arendt' view (1969, p. 44-45). For Arendt, authority rests upon personal respect as opposed to coercion or persuasion.

[156] It must be noted that this definition of authority is at odds with several traditions in social sciences. It does neither stem from ideal-types of legitimate rule (Weber), nor from the persuasive force of "respect" (Arendt), and it is still less resulting from the leadership properties of hegemonic positions (as suggested in early regime theory). In addition, the question of legitimacy might be seen as related to the issue of authority in IR (see Mulligan 2006). As suggested here, however, legitimacy is conceptually different from authority. The concept of legitimacy is mainly related to a reflective process of deliberation and representation that occurs in the grouping of assemblages that could be labeled "modern states".

effects.[157] To "act in concert" is difficult to achieve – especially, against the backdrop of a hybrid world full of contradicting, shifting, and multi-directional agencies. As technological innovations occur within or across assemblages almost everything can turn into a matter of negotiation. When the back and forth of translations is ubiquitous, the attribution of agency becomes a pressing real-world concern (MacKenzie 2009). The concept of authority refers to *innovating actors who bring about translations, replacements, and ultimately stabilize assemblages*.[158] Crucially, neither power nor authority is restricted to intentional actors/acts. Under the above-mentioned circumstances, logics of coercion (power from or over capacities), which seemingly cause others to do what they otherwise would not do, may complement "network power" but are no substitute.

As a foundational collector, the concept of "assemblage" offers a viable path to overcome the lightness of IR. To study the modern state through the lens of assemblages is only one option (Passoth and Rowland 2010). Other assemblages might stretch around the entire globe and might be collected through the authority of religion, ethnicity, family, agriculture, or "criminal" activities. The conceptual world of assemblages carries a greater resemblance with the realities of global politics than the logocentric premises and concepts of many other IR theories. Sloterdijk correctly points out that the main task, then, is "describing the togetherness, the communication and the cooperation of the multiplicities, who are held together under the stress of coexistence in their own space, but who are unfortunately still referred to as societies, on their own terms" (Sloterdijk 2004, p. 293, cited in Jongen 2011, p. 213). But the empirical diversity of assemblages requires some form of differentiation.

8.4 Towards classifications of assemblages

The sheer diversity of assemblages raises the question whether we should elaborate different types or classes of collectives to enable comparisons of case studies across

[157] Perhaps the vague usage of term of "great power" in early IR, which scholars and observers used to signify expanding empires (cf. Meyers 2006), comes closest to the perspective that is suggested here.

[158] If this still appears absurd just remember the worldwide response to things such as a nuclear Armageddon, the millennium crash, or consider the fight against the proliferating agency of the first major cyber-robot "stuxnet".

historical periods and divers modes of existence (see Latour 2005, pp. 238ff). The question of classification is problematic from the outset. It must remain without a definitive answer. Categorizing assemblages is done at pains and only by avoiding a fixed set of categories. No hierarchic order should be imposed upon the jungle of assemblages, although I do believe that attempts to classify are necessary—in one way or the other—to carry out further research because classifications help navigating through these unexplored lands. They organize puzzles and render phenomena and cases intelligible. Also, we need more than a mere "list of the elements always present in controversies about groups" (Latour 2005, p. 31). In particular, it is crucial to distinguish, if only rudimentary and preliminary, between assemblages in order to theorize the shifts in power and authority involved in technological innovations. In an explorative spirit, the aim is to indicate diverging sets of possible classification methods. Three options will be considered: firstly, the size of assemblages; secondly, a refined Weberian approach of ideal-types. Finally, I consider a classification that grants non-human actors, and particularly technologies, the defining role. This cartography of assemblages, then, is centered around non-human agencies and highlights different ways of capturing the characteristics of assembling.

ways of classifying	**core criterion for differentiation**	**perspectives on technological innovations**
size-based comparison	number and diversity of assembled practices and actors *(power)*	magnitude of challenges confronting authority magnitude of achieved translations
typology of ideal-typings	coherent scripts politics of ignorance	technologies becoming matters of fact or matters of concern
cartography of material agencies	topologies of non-human connectivities	shifts or extensions of technical and logistical interoperability

TABLE 8.1 CLASSIFICATIONS OF ASSEMBLAGES AND TECHNOLOGICAL INNOVATIONS ©AUTHOR

Table 8.1 provides a distilled account of the three options for categorizing assemblages.

While preliminary and open-ended, it articulates the possible differentiations. All classifications possess advantages and limitations in characterizing assemblages but their comparison helps differentiating processes of technological innovation in illuminating ways. The size-based comparison; the typology of ideal typing, and the cartography of assemblages centered around non-human agencies highlight different ways of capturing the characteristics of assembling.

The *first* option to distinguish assemblages is comparing their size. In a rough approximation, size could be measured as a function of the number and diversity of actors and practices that are associated (Mayer 2012a). We may start with a modest sized, yet already rather complicated, assemblage such as a combustion engine. Automobiles are already a bit larger involving more agency and actors. Cars, in turn, could be seen as crucial components of even larger assemblages of traffic and transport. Transport systems, at the same time, are but one element among others in the mega-sized "petroleum assemblage" that encompasses diverse human and non-human actors, economic, political, military, and criminal practices, and numerous connections across the entire planet. Because large assemblages rely on an extraordinary high number of black-boxed actors, which could at any time turn into intermediaries that cause controversies, we can employ controversies as an additional measure of size. Moreover, as this way of categorizing counts the number of actors performing in concert, a comparison of the "power" of an assemblage becomes possible.

Measuring the size of an assemblage does not resemble computing stylized sets of variables (i.e. "power capabilities"). It is not comparable to neorealist frameworks (cf. Lebow 1994) which ignored sociological understandings of the significance of technological change for the size and power of political entities (see Ogburn 1949). Rather, this classification combines a qualitative and a quantitative approach. As a rule of thumb, large assemblages have more power than small ones because they connect and coordinate more actors, practices, and materials. The resulting "mode of existence", produced by acting in concert, has a larger geographic, epistemic, or temporal extension. For example, one could compare in such a manner the power of the "petroleum assemblage" with the power of a "state-assemblage" (see Sampson 1975, Mayer and Schouten 2012, Hoyos 2012). Qualitatively, the difference in size has significant implications. The bigger the size of an assemblage, the more durable and encompassing are the modes of existence that it creates.

What does a classification based on size imply for the understanding of technological innovation? Inquiring the number of assembled actors renders tangible the extent to which the accumulation of earlier technological agencies has enabled power. In turn, this classification emphasizes the inertia and difficulties that possible technological innovations might face. It puts the *magnitude of translations* (MOT) into the spotlight: that is, the amount of authority that is necessary to invest into processes of negotiation, replacement, and enrollment necessary in order to realize a technological innovation. The size of an assemblage, in general, correlates positively with the MOT. An assemblage becomes more difficult to shock into change as it gets bigger. Consider, as a thought experiment, the different magnitudes of translation that are warranted for the realization of "decarbonization" – depending on whether bio-fuels are introduced, the automobile is supplanted, or the entire petroleum assemblage is replaced,[159] the implications of the scale of different technological innovations become obvious. The bigger an assemblage has become, the more translational "energy" is necessary to unpack and destabilize them. In this sense, studying the size resembles a method to de-flatten the power political landscape of assemblages as layered and reconfigured through successive technological innovations.

The *second* possibility to categorize assemblages draws on Max Weber's methodology of ideal types. Weber postulates a close correspondence of subjective meanings and social structures (generated by actions) which sociology can captures by the notion of ideal types (Weber 1964b, pp. 4-15, Hekman 1983). At first sight, this seems counterintuitive because ideal types presuppose that we can grasp our subject matter merely based on meaningful motives and, thus, intentionality, whereas a post-Cartesian definition of agency claims going beyond human intentions. Indeed, Weber explicitly stresses that artifacts remain external to his approach of *verstehende Soziologie* and are only be understood through the rational meaning that humans may bestow upon them (Weber 1964b, p. 5, 9) So, even if we assume assemblages with a high density

[159] Total "decarbonization" might constitute a truly revolutionary endeavor (Litfin 2003, Mitchell 2011).

human actors, the Weberian methodology needs to be revised in order to provide meaningful criteria for difference. This can be achieved by three changes of the original ideal type methodology.

One the one hand, Weber's concept of "motives" (*Sinnzusammhang*) that constitute the reason of *individual* actions, and from which social scientist can carefully construct pure or ideal types (1964a, pp.8-9), is replaced by the notion of "script" (see Akrich 1992). Scripts operate in heterogeneous assemblages and refer to more or less coherent programs of action for putative users of technologies. Against Weber's one-way determinism, technologies and scientific objects can alter the program of action of users and so can users alter scripts designed into technology by producers (Latour 1992a). Weber's individualist-rational assumptions, in addition, give way to complex and mediated forms of agency. Scripts as understood here imply a form of meaning that is more ambiguous, flexible, and instable than Weber's motives.

On the other hand, the construction of ideal types is understood as an unconstrained, constant, and infinite practice. Going beyond Weber, the range of actors who conduct "ideal typing" does not only entail scholars; it potentially involves all subjective actors of an assemblage. Ideal typing, then, does not resemble a procedure that assumes a divide between subjects and objects. It rather captures the *interactions and intermingling* of economists, IR scholars, legal scholars, philosophers, priests, biologists, engineers and many others, though separated by disciplinary boundaries, who (en)frame the world—directly influencing the very assemblages under construction, examination, or conceptualization (Shaw 2003, Ashley 1988, Latour 1993).

It needs to be pointed out that language is not a mute vessel. In contrast to Weber's original methodology, ideal typing assumes travelling vocabularies. There are no barriers between academic and vernacular discourses. Words, concepts, and metaphors inevitably move back and forth between laboratories, universities, and research institutes on the one hand and the "outside world" on the other. Actors enrolled through this process are constantly up-keeping and, at the same time, reframing assemblages. Collectives are distinguishable through the practices of "ideal typing" because specific scripts and inscriptions co-constitute and stabilize specific subjectivities, agency, and collective practices (see Walter 2002).

Caliskan and Callon (2009, 2010) describe the practice of economization—that is, an ideal typing of “the economy”. They suggest a pair of concepts including “subjectification” and “objectification”. These concepts denote the mix of legal, political, business, and scientific practices whereby actors get enrolled and transformed to become consistent elements. In due course, preexisting practices and subjectivities are completely translated according to the *script* of the “market assemblage”. Consider the ways in which divers materials and technical and scientific efforts have been turned into “fictitious commodities”—to employ Karl Polanyi’s phrase. As bioprospecting and the clean development mechanism indicate, commodification is an ongoing process that replaces properties of actors and breaks apart existing assemblages and establishes materials as *legible* to governed by new institutions and rules (Jasanoff 2006). To trace ideal typing processes of commodification is a powerful way to study the role of technologies and materials in making the world (see Coole 2013, p. 466).

Scientific knowledge production resembles another form of ideal typing. To translate a questionable claim, which has been ignored at the political level, into a “matter of fact”—that is to objectify knowledge, which henceforth becomes relevant for policy—scientists must actively assemble. In a “procedure for collecting new associations of humans and nonhumans” (Latour 2004b, p. 238), they enroll the material actants by means of instruments, and ensure the autonomy of scientific knowledge, at the same time forging alliances in order to receive research funding and represent their knowledge to the general public (Latour 1999a, Bueger and Gadinger 2007). In the case of climate change, actors from multiple professional and disciplinary backgrounds collaborate in order to produce reliable expertise. The stabilization of such a heterogeneous network requires to synchronize research work, facilitate communication among different professional groups, and to reinforce scientific authority (Jasanoff and Wynne 1998, Shackley and Wynne 1996). Another symmetrical way to think about scripts is presented by Jasanoff’s comparative work. For instance, in design on nature she shows the diverting ways in which law, science, and new technologies (in this case gene technology) emerges in different countries (Jasanoff 2005). The concept of sociotechnical imaginaries opens to possibility to compare different assemblages around large technical systems, such as civilian nuclear technologies, across countries (Kim and Jasanoff 2009).

Insofar as we could simply distinguish a list of assemblages due to specific scripts or programs, this classification reveals serious shortcomings. Given that the likely items on our list of scripts contain law, economy, religion, science, music and so on,[160] such a list would lead us to probe into assemblages such as “states”, “markets”, “church”, “nations”, “empires”, “epistemic communities”, “prison camps” alongside with “orchestras“. This sort of classification amounts to rebranding preexisting concepts. It is misleading because categorizations based on coherent scripts are problematic. Assemblages are seldom sharply defined by a single clearly scripted meaning/logic/reason. Take the example of a commodification process that translates ancestral lands, personal information, or physical properties into monetized and tradable goods. This process is believed to be indispensible for the construction of free markets. And yet, these transformations typically involve endemic corruption and plunder by a few actors that happen to be at decisive positions. To analyze the actual replacements that were negotiated in their favor and rendered them obligatory passage points, however, cannot be achieved by reference to “market” scripts.

The practice of ideal typing can also be misleading since scripts are often not implemented in a coherent manner. The script of “sovereignty” has seldom worked as it was supposed to do (Krasner 1999, 2001, Howland and White 2008). Only in very few instances have actors managed translations that led to presumably unquestioned scripts and coherent routines. Social scientists regard “states” and “markets” among them. But even granted the existence of coherent scripts, one must acknowledge that their specific meaning tends to change over time. The scripts of “state assemblages” may radically alter over time as Arendt, Foucault, and Sennet brilliantly show in their research. Employing ideal typing thus inevitably leads to historicizing perspectives, which are, however, unfortunately underrepresented in IR that rather thrives on universal or ahistorical categories (see Vaughan-Williams 2005). Historically, scripts remain fluid and inconclusive. The heterogeneity of assemblages ultimately suggests that scripted practices such as sovereignty actually are *never* able to escape incoherence.

[160] This resemble in a way Latour’s approach of “modes of existence“ (Harman, 2016a,c)

Inadvertently, classifications built on this sort of comparison rest on shifting sands.

Ideal typing, it must be repeated here, always implies a symmetrical reading. Thus, if we recycle existing concepts we should not forget that we *symmetrically* refer to radically different subject matters by now. A focus on ideal typing could easily cause one to understand assemblages as distinguishable because they constitute vessels filled with "political", "social", "technical", "legal", "scientific" or whatever kind of pure relations respectively.[161] But it would be a mistake, if accounting for ideal typing would lead us down the road of "great divides" and other artificial separations (as reviewed in chapter 3 and 4). While Cartesian social science all-too-commonly accepts the purified domains imposed onto the world that already underpins Thomas Hobbes' Leviathan (cf. Shaw 2004, Williams 1996), ideal typing is to be explored based on a monist understanding of ontology (Jackson 2001).

Consider once more the example of "state assemblages". Needless to say, the term does not indicate national containers or sovereign units; neither is it confined to the triple-corset of a limited territory, people, and legal authority. Like all other assemblages, states are stabilized through complex practices that may traverse the inside/outside delimitation, the global-local nexus, the micro-macro levels as well as the social-material distinctions. Unless we employ a symmetrical methodology we neither can explain which attributes and properties characterize state assemblages, nor what maintains their existence in the first place. The brilliant works of Benedict Anderson (1996), James Scott (1998), Isabelle Stengers (1997), Thomas Mitchell (1994, 2002), and Mark Duffield (2006) illustrate how the principle of symmetry (albeit used in differing ways) excavates significant, yet unexpected connections between humans and non-humans and technological agency that "explain" states in the first place.

A crucial supplementary possibility for ideal-typing-based differentiation arises as assemblages differ in what they "silence". The notion of silence here refers to externalized consequences of practices. For instance, certain stable assemblages may

[161] Prominent cases of ongoing global controversies include "climate change", "genetic agriculture", and "bio-piracy" that actually force social scientist to take at face value the messy reality, a reality in which the supposedly "clean" domains are hopelessly mixed up (Gray 1991, Castree and Braun 2001, Brand 2010, Mayer and Arndt 2012).

ignore inherent hardships such as destruction, violence, or pollution. Silence indicates assembled elements that are taken for granted. These “black boxes” are bereft of agency as noted above. But silenced things, that is, matters of fact, can become problematized as “matters of concern” in any moment. As such, the specific “politics of ignorance” greatly vary among assemblages. The assemblages of “energy security” and “environmental security” are a telling pair of examples. The former sees oil platforms and pipeline networks as technical black boxes (vital for energy security) and silences carbon emissions and environmental degradation as external issues. The latter takes the very same material objects as “matters of concern” (threatening environmental security); the concern with environmental impacts of oil production and usage is inherent to its script of security (Mayer and Schouten 2012). When technological innovations move along a gradient between unproblematic fact and political concern they tend to involve controversies that disturb coherent meaning. The shifting politics of ignorance is a key site to investigate the potential of innovations to destabilize practices of ideal typing. In turn, emerging technological innovations also complicate this type of classification.

The *third* option to classify assemblages sets out from an altogether different starting point. Taking serious the “topology of agency” it focuses on which kind of non-human actors prevail within an assemblage.[162] What here springs to the eye are altogether different species of assemblages in which rational practices of “ideal typing” are largely insignificant. This does not mean human actors are completely absent. But at the core of this type of assemblage the affordances of different materials (see Ash 2013) as well as interoperability and inter-lockage between technological systems and artificial components—often entailing a planetary scale. Recognizing the minor importance of scripts is also critical for the research methodology: “topological” assemblages require a cartographic approach featuring “real types”.

Whereas IR theories shed light on several of the ideal typing practices, even though by neglecting their material underpinnings, they have overseen topological assemblages. Authors exploring material culture (e.g. Appadurai 1986, 1996) and logistics (Belanger and Arroyo 2012) challenge the neglect of these seemingly incomprehensible or

[162] This classification comes close to the Object Oriented Ontology as proposed by Graham (2016b, c).

“meaningless” assemblages that are downplayed by social sciences. Proponents of an object-oriented ontology have advanced research in the same direction (Graham (2016c). Indeed, it can be argued that they proliferate in numbers, grow in extension, and actually make up the lion’s share of all existing assemblages. Examples of this type of “acting in concert” include the “car assemblage”, “metropolitan assemblages”, the “plastic assemblage”, “production networks”, “waste recycling assemblages”, the “coffee assemblage”, “resource extraction assemblages”, the Internet’s “International exchange points” and “encryption chain assemblages” and so forth. A good measure for their growing size and number is the accelerating consumption of raw materials such as sand, water, iron ore, copper, timber, rare earths, and minerals. These assemblages can be seen as more powerful because they are less visible – they are simply relayed to the background of other assemblages.[163] The scripts and program at work, equally, are buried in scientific discourses of logistics, finance, and engineering rather than being part of public political deliberations.

But what glues these assemblages together? The “container assemblage” evolving around the intermodal shipping container is a prime example (Mutlu 2015). The cargo container, write Alan Sekula and Noël Burch (2011), “has radically changed the space and time of port cities and ocean passages”, “a modest American improvement in cargo logistics has now taken on world-historic importance.” Over decades, it globally enrolled innumerable companies, new markets, seaport infrastructures, just in time procedures, production networks, 100,000 ships, choke points, the “flag of convenient” system, dockers, cranes, security practices, economies of scales, shipyards that build mega-bulk carriers, cargo logistics, trade policies, and so forth (Murphy and Yates 2009, pp. 46-67). Of course, human actors within these assemblages could be singled out as somehow linked through standard setting, market mechanisms, and rational economic behavior at the “micro-level”. Yet, “the containerization of the International” (Mutlu 2015, p. 64) becomes intelligible if we put the agency of the cargo container at center stage: “the containerization of the International”. The agential topology is distinct. Anonymous logistical connectivity dominates this kind of assemblage. The logic of a standardized

[163] Thanks to Peer Schouten for raising this point.

metal box overrides meaning-based practices: particular scripts and individual human subjectivity and intentionality in general. The presence of materially mediated agencies is overwhelming vis-à-vis human actors.

Why did these assemblages so readily stay below the radar beam of social scientists, and especially IR theories? One possible explanation – aside from object-disinterested European philosophy (see Harman 2016a) – is that the predominance of material mediators often results in a lack of "public faces", visible leaders, or outstanding heroic characters, which are so familiar to ideal-typing assemblages and, more generally, akin to the dominant social narrative relevant for political theories. One would mistakenly conclude from the absence of highly visible spokespersons—or perhaps a missing human feeling of 'hominess'—that these assemblages are marginal as is pointed out in Parag Khanna's *Connectography* that brilliantly traces how myriad technical networks and associations structure foreign policy, firm activates and state interventions all over the world (2016).

A second, perhaps more significant reason for why we have failed to comprehend the significance of these vast assemblages is simply that their scale and evolution are hard to grasp from a human perspective in the first place. George Kubler's (1962) impressive study, in this vein, shows that although humans live in the midst of large ensembles of artificial things which they have produced over millennia; understanding the duration, interrelated sequences and serial evolution of these "things" requires a dramatically different conceptual language. As such, movies, novels, and photography offer invaluable insights. For example, Paul Auster (1988) depicts the incomprehensibility of the immense material environments of megacities that are overwhelming and immersive for human experience, rationality, and bodies in *The New York Trilogy*. Likewise, Haruki Murakami, in *Hardboiled Wonderland and the End of the World* (1985) and in *Norwegian Wood* (1989), describes human experiences and conditions of consciousness that are per se enmeshed in Tokyo's chaotic metropolitan techno-spaces.[164] Mega cities resemble cases of "material assemblages" that are most immediately appealing, but there is more.

Edward Burtynsky's photographic oeuvre and his documentary *Manufactured*

[164] See Nigianni (2003), Swope (2002), Takagi (2010) and Cassegard (2001).

Landscapes broaden the perspective. Burtynsky brings to our attention the environments that we would not necessarily accept as part of our "world": the vast deserted landscapes, the abandoned infrastructures of grotesque proportions, and the macro-scale technical and natural transformations that are linked to extracting crude oil, coal, precious metals, and rare minerals, giving rise to "resource assemblages". From yet another angle, author Annie Leonard has paved an inroad to the alien agencies of materials.[165] Her *Story of Stuff* opens a window into the extensive world of artifacts permeating our daily lives—including its polluting and anti-human consequences (Leonard 2010, Bennet 2010)—that usually is silenced by social theories.

To sum up, a preliminary cartography distinguishes between four different topologies:

- mapping technical and logistical agencies (machinery, gadgets, buildings, military and research installations, cyber/virtual world, clinics, walls, urban, industrial, and traffic infrastructures et cetera)
- mapping material resources (drugs, natural raw materials, crops, oil, coal, timber, gold, garbage et cetera)
- mapping geographical and climatic environments (mountain regions, islands, climatic areas, desert and forest areas)
- mapping physical-biological-chemical webs (laboratory sciences, scientific research, energy use, particle emissions, human activities embedded in "ecosystems")

Needless to say, this cartography is open-ended and not intended to be exhaustive. The third and fourth topology are in need of further clarification. Talking about geographically centered assemblages, of course, does not entail any structural or deterministic readings. James C. Scott (2009), among others, has demonstrated—although employing a different conceptual terminology—how geographical conditions are central actors in assemblages without resorting to determinism. In addition, we also

[165] This issue is extensively examined by human geography. The special edition of the *Journal of Cross-cultural Studies* (2010, Issue 2-3) offers a combination of photographic materials and theoretical reflections. For the illuminating pictures by Edward Burtynsky see: www.edwardburtynsky.com. More about the "Story of Stuff" is told in http://www.storyofstuff.org/.

should carefully re-read determinist accounts because non-vulgar writings often pertain more lively descriptions of agencies than implied by their theoretical apparatus (e.g. Diamond 2005).

In this vein, claiming that IR has overseen material assemblages, as I do above, has ignored some exceptions. Classical realism addresses the "stopping power" of oceans. Since "water is a forbidding barrier" realists assume that navies which project power suffer from structural disadvantages. This "objective" fact determines to a certain degree great power politics despite technological progress (Mearsheimer 2001). Obviously, recent strands of realism have not reexamined the objections to the pioneers of geo-strategy such as Mackinder, Mahan, and Innis many of whom have clearly recognized the interplay of revolutionary transport and communications technologies with material environments (see Chapter 2). So, while the older realist generation has conceptualized material topologies in a more or less meaningful way, contemporary realist approaches have, in terms of theoretical sophistication, retreated a step behind Mahan and Mackinder.

The last topology focuses on physical-biological-chemical processes that do not only fall under the domain of the "natural sciences" but are—as climate change—often at the center of human history and political decision-making (McNeill 2001, Cohen 2001, Dalby 2009b). In this sense, assemblages can complement approaches such as "social metabolism" that analyze the interplay of human activities and ecological systems addressing "technical domination" (Fischer-Kowalski and Haberl 2007). Mapping assemblages, however, offers a post-Cartesian methodological corrective to the mechanistic and dualistic mode of analysis inherent in the social metabolism approach.[166] Following physical-biological-chemical webs quickly leads one to scientists, laboratories, simulations models, NGOs, think tanks, and politicians as I have shown elsewhere (Mayer 2012a).

The last topology highlights a possible totality, that is, a reference point for normative deliberations. If many natural scientists view "Gaia" as the ultimate planetary

[166] The same applies to the world system theories that include ecological processes as components of accumulation (see Hornborg 1993, 1998).

body that encompasses all other collectives (Brauch, Dalby and Oswald Spring 2011, Dalby 2009a), the fourth topology instead stresses global interconnectedness. Philosophically speaking, this totality sees humans as a truly global force altering the ecological parameters on a planetary scale. It radically diverges from most what is interrogated within IR at the moment. Instead of lamenting the inescapability of the "inter-national"[167], it suggests that we engage in cosmopolitarian debates about the consequences of the Anthropocene that momentarily evolve without a substantial contribution from IR (Linklater 2009, Dalby 2009b).

8.5 Summary

The three classifications explicate now the concept of assemblages can be used as a foundational collector. It must be noted that assemblages are, in situ, not always clearly distinguishable because they may actually overlap, merge or appear to mix up. During controversies, actors may voice conflicting claims to hierarchical order. As different assemblages are often layered or connected without discernable hierarchy, the same actors (having multiple agencies or properties) also can be enrolled in various assemblages. These observations lead to the conclusion that different ontologies are experienced in parallel or ontological pluralism (Mol 2002, Dobres 2010, p. 110, Latour 2012). Ontological pluralism and controversies complicate the applicability of a priori differentiations. For sure, one should not confuse the map with the territory (see 6.1). These classifications offer tools of distinction that need to be adopted while encountering empirical materials. Ordering diversity to a certain degree—without a fixed hierarchical grid—prepares us for exploring the relationship between assemblages and creative destruction. Given their ubiquity and significance from a historical perspective, technological innovations have played a crucial role in creating or have significantly altered all four classifications, as will be detailed in the next chapter.

[167] See, among many, Walker (2006, 2010).

9. Varieties of creative destruction

> From time to time, and always in time, new forms emerge that catalyze previously existing actors, things, temporalities, or spatialities into a new mode of existence, a new assemblage, one that makes things work in a different manner and produces and instantiates new capacities. (Rabinow 2002, p.180)

This chapter elaborates how technological innovations relate to assemblages. Drawing on Schumpeter's idea of creative destruction, three models are developed that distinguish processes of stabilization and destabilization. The first model considers technological innovations as "assembling", which if successful leads to the establishment of a new assemblage. The second model explains how technological innovations animate the "reassembling" of an existing collective. The third model focuses on the process of "disassembling" that results in the complete dissolution of an assemblage. While the three models operate based on a clear analytical separation, the actual processes often occur in combination or sequence. The chapter employs empirical cases to illustrate how and to which effect the varieties of creative destruction involve shifts of "power" and "authority" within assemblages, offering an alternative lens to grasp the transformative changes of historical and contemporary global techno-politics.

9.1 Assembling

Creative destruction has a double meaning. On the one hand, it highlights the creativeness of all involved actors that is necessary for assembling. Chapter 8 has shown that this involves the replacement of identities, interests, routines, and properties—otherwise no actors would be assembled into a collective in the first place. Or, to phrase it diffently, every new technology has to become part of an assemblage (Bousquet 2014). When new authoritative actors start to construct new collectives, they don't employ force but use their ability—during a process of translation—to negotiate, objectify, and stabilize; in short, they convince other actors to become part of an emerging assemblage. On the other hand, Schumpeter's terminology emphasizes the resulting "destruction" that inevitably follows from innovation.[168] Schumpeter thought that innovations revolutionize "economic structures" (Schumpeter 1943). While his theory is focused on the "economic" aspects of innovations, the following discussion broadens the perspective by assuming that innovations reconfigure collectives of humans and non-humans.

The birth of an assemblage constitutes a three-step evolutionary process.[169] In a nutshell, the story of assembling starts with an invention, a concern, or a vision. It goes through a translation phase of innovating activities until a stable technical artifact gets constructed. The artifact is stabilized because it is embedded into new practices, enmeshed in identities of manifold actors and entrenched with numerous interests and routines. Technological innovation, therefore, is never happening outside of "society" but involves a mixture of human and non-human actors.

Figure 9.1 condenses and extends existing STS literature (Latour, Maguine and Teil 1992, Latour 1999a) to capture the conceptual links between creative destruction and assemblages. This process model assumes that a "thing"[170] that initially was ignored or unknown (i.e. an invention) can become controversial and initiate the assembling of a potentially large assemblage that is unknown in its evolution, actors, and subsequent extension. The model plots the evolution of assemblages along two dimensions explicating certain aspects of creative destruction. The x-axis refers to the translation process and the y-axis the size of an emerging assemblage. The x-axis is (for analytical purposes) divided into three layers: practices of group formation, the status of material/artificial objects, and different forms of politics. Moreover, the x-axis represents in a stylized way three temporary phases of translation that can be distinguished.

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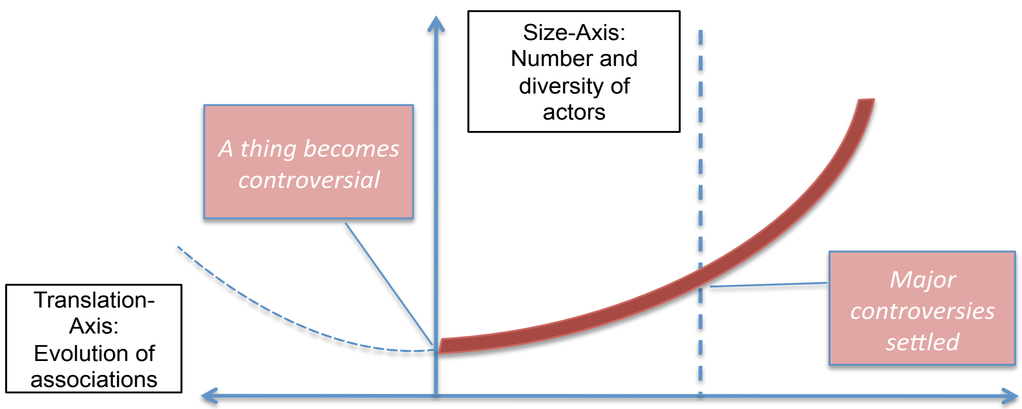
[168] Historically, the process of creative destruction as a whole cannot be stopped. But this does not mean that creative destruction always unfolds inevitably. Just consider the first historically known anti-proliferation initiative conducted by the Catholic Church against the spread of bows and crossbows in medieval Europe (McNeill 1982). This ban had not succeeded. And the mighty assemblage of knighthood had to adapt its armory to the new cheap and deadly weapons. The protective measures grew to a point of "gigantic absurdity" at which King James I of England reportedly remarked that "it kept the knight from being injured, and second, it kept him from injuring anybody else" (Brodie and McKay 1973, p. 37, Ruff 2001). The record is much better when it comes to technological innovations such as chemical and biological weapons that have been banned from proliferation and usage (Price 1995). So, in a few cases creative destruction was prevented.

[169] Although I will here exclusively focus on *technological innovations as assembling*, assemblages can be constructed in several other ways.

[170] Following Latour, a thing (or a person) is seen as an "assembly of a judicial nature gathered around a topic, reus, that creates both conflict and assent." (Latour 2000, p. 117)

The term translation was already introduced in the context of agency and classifications in Chapter 8. Here, it can be further elaborated based on the phases and layers shown by the x-axis of figure 9.1. In the process of translation actors start to assemble and establish new connections (red arrow) while matters of concern eventually over time turn into matters of fact. In this sense, the y-axis represents another aspect of stabilization: the higher the number and diversity of human and non-human actors enrolled in an assemblage, the more stable and powerful will an assemblage become. Given the heterogeneous and fluid world of assemblages, the trajectory of an assemblage is always reversible and its stable condition of temporary endurance.



Practices	Assembling	Stabilizing/objectifying	Stable association, uncontested practices
Materials	Diverse, unconnected actants	Matters of concern Boundary objects	Matters of fact Obligatory passage points
Politics	Ignorance	Controversies	Epistemological Hegemony

FIGURE 9.1 STYLIZED MODEL OF THE EVOLUTION OF ASSEMBLAGES SOURCE: MAYER (2012A) ©AUTHOR

What is the motivation of actors to assemble? Notwithstanding the narratives in which technological innovations were realized by engineers, scientists and entrepreneurs—and, less important, state bureaucracies, many different motivations can drive the hard work of collecting, including beliefs, visions, profits, truth, glory, aesthetics, enrichment, dreams, adventurism, and so forth. As John Darwin points out in *Unfinished Empire,* the assembling of even the biggest political power structure has worked without a "master plan"; without a guiding ideology; without a fixed and centrally coordinated set of practices (Darwin 2012). In this sense, the core question is not what motifs make collectors to do the assembling, but how they overcome the challenges and the obstacles. Actors who assemble successfully must possess the ability to overcome ignorance and to connect all different human actors and practices. This ability refers to the term "authority" in the context of translations. In addition, assembling also requires the enrollment of an array of non-human actors.

While innovating actors are important, it needs to be pointed out that novel technologies cannot be simply controlled. There is no single actor—presumably at commanding highs—who can conduct or manage the creative process in a top-down manner. The enormous expansion of coordinated action that a successful innovation presents (to which Chapter 8 refers to as the increase of "power") is only due to the authority of the many. It cannot be boiled down to state policies or national innovation systems—though an array of actors that are often wrongly subjected to the concepts of "state" play important roles. The idea of a coherent "state" does not reflect the empirical reality of innovational processes as is shown by McNeill's (1982) brilliant study of innovations in weapons and defense systems. Similarly, the evolution of the "nuclear assemblage", which has been discussed in Chapter 2, illustrates that we cannot foresee the creative process of translation, partly, because, the later tend to decompose container-like entities, facilitating the agency of many different groups (see Adler 1992). Another current example for the contingency of assembling is the "virtual assemblage" which enrolls users, electronic networks, images, property laws, businesses, regulations and so on. All this constitutes a back and forth without a clear plan or a design (Bessette and Haufler 2001, Lemley 2012).

The operation of collecting intensifies during the second phase. A series of controversies arises during which the identities and goals, and the relationships among the involved actors are "a series of negotiable hypotheses" (Callon 1986, see also Nelkin

1979)[171]. In an assembling process, according to Michel Callon, the situation remains in flux because of the agency of all actors involved. Gabrielle Hecht's work on "nuclearity" of things exemplifies how the ontological nature of materials can become contested and subject to international negotiations (Hecht 2010). Her work also indicates that an assemblage is stabilized only after various unexpected and unpredictable adjustments and transformations. Callon, in his famous study on the fishermen of St Brieuc Bay, describes "translation" as follows:

> "Translation is the mechanism by which the social and natural worlds progressively take form. The result is a situation in which certain entities control others. Understanding what sociologists generally call power relationships means describing the way in which actors are defined, associated and simultaneously obliged to remain faithful to their alliances. The repertoire of translation is not only designed to give a symmetrical and tolerant description of a complex process which constantly mixes together a variety of social and natural entities. It also permits an explanation of how a few obtain the right to express and to represent the many silent actors of the social and natural worlds they have mobilized." (Callon 1986, p. 19)

Only after multiple positionings, controversies, and negotiations can a new association finally reach a stable state. Although Callon does not speak of technological innovations, his insights similarly apply. Several competing versions of an innovation that, later, seem to be a self-evident entity with an unquestioned form may have existed in parallel for a long period. For example, the form of the bicycle and the light bulb, which is taken for granted today, was totally unsettled for decades until a single model supplanted competing versions (Bijker 1997). Who would have thought that cars, by the turn of the last century, would not become predominately electric automobiles as vehicles with a dirty and malfunctioning combustion engine struggled to increase their market share. The automobile was not inevitably linked to fossil fuels (Yergin 1991). Similarly, who would have thought that basic technical specifications of electricity would be contested for decades (Schiffer 2008) while the engineers innovating electricity grids and long-distance communication had to struggle for decades to convince users, businesses and politicians

[171] Four a similar flexible model of negotiations, though it does not include "actants", see Singh (2008, pp.18ff.)

to assemble accordingly (Hughes 1983). In addition, the prolonged situation of ambiguity is also mirrored by complex and unpredictable political choices[172] as well as the difficulties of law to regulate and govern technological changes and their consequences (Bennett Moses 2007, Lemley 2012, Jasanoff 2011).

The question, then, is how a translation process ends given that the authority to assemble does not rely on the use of force or coercion. It does not happen autonomously. Indeed, many technological innovations were canceled after years of unsuccessful assembling (e.g. Law and Callon 1988). So, which mechanism is at work here? An insight from STS is to look for "boundary objects" (Star and Griesemer 1989). In short, actors can solve controversies gradually since boundary objects become focal points of translation processes. To the extent to which artificial objects (regardless whether small, complex or large scale in nature) become boundary objects, they constitute sites where the struggle of connecting human and non-human actors unfolds.[173]

Boundary objects are used pragmatically to articulate shared problem definitions and joint priorities for action regarding a matter of concern. They are interfaces enabling "the weaving together of a multitude of different elements which renders the question of whether they are 'scientific' or 'technical' or 'economic' or 'political' or 'managerial' meaningless." (Latour 1987, p. 223)[174] Boundary objects such as metaphors, devices, images, and machines et cetera enable various actors from heterogeneous practice fields and professional contexts to connect and negotiate. In science, for instance, boundary objects synchronize research work, facilitate communication among different professional groups, and reinforce scientific authority (Sundberg 2007). Boundary objects

[172] Consider as an illustration the different, but interrelated, concerns that Winston Churchill confronted when he had to decide whether or not to switch the entire British fleet from steam to oil engines in the year 1911. Among his concerns were the altered range and speed of battle ships, the anti-innovative stance of the admiralty, the unknown volume of reserves and the reliability of crude oil, the massive global security measures on which the British Empire would get dependent on to secure oil for its naval superiority, engineers' methods of determining crude oil deposits, the consequences for British naval strategy, and so on (Yergin 1991).

[173] I have selected here only technological innovations but it could be argued that every innovation (say in management, science, culture, philosophy, or policy) is somewhat based on novel material components, instruments or devices as well. Take as an example the Copernican revolution that was partly enabled by new telescopes (Feyerabend 1975).

[174] MacKenzie's study of the design of strategic missiles shows that to stabilize the meaning of "precision" required the mobilization of actors and agencies across all domains (MacKenzie 1987).

play a pivotal role in the process of translation and help to put actor into position, standardize possible ranges of agency, and structure identities all human and non-human actors. Negotiations organized around "boundary objects", by definition, involve the (partial) replacement material characteristics of novel technologies, collective practices, and political priorities.

Sometimes, boundary objects cannot facilitate a stable assemblage. An example for the difficulties of translation is the global negotiation about climate change. Due to the "global circulation models"—a crucial boundary object in this field—few actors deny the fundamental ecological interconnectedness of "human activities" and bio-chemical or physical processes on a planetary scale. Yet nearly 25 years of research failed to produce a common definition of the matter of concern and, thus, stable prescriptions to solve the problem (Mayer and Arndt 2009, Hulme 2009). This holds an important lesson for technological innovations. Only in retrospect do they seem to have followed a linear "technical" development trajectory, whereas their actual translation phase was full of twists, uncertainty and contingency: a history that is largely forgotten later on, however.

When things reach a point of "a constraining network of relationships" (Callon 1986, p. 15) a new assemblage finally is stabilized. Figure 9.1 depicts this last phase of assembling by the orange-inked areas at the right side of the x-axis. All concerned actors are collected, enrolled, and transformed into coherent parts of an association—each in a new position, endowed with a fresh role and with altered properties—a sort of concert in which all voices are "speaking in unison" had been established (Callon 1986, p. 19). Accordingly, the material and epistemic layers of an association have reached a structured condition. Practices have been routinized and are carried out uncontested. Boundary objects were transformed into obligatory passage points (Latour 1987, p. 150). The flat ontology of translations became, in other words, structured.

What is the essence of this stability? Let's begin to answer this question by looking more closely at "obligatory passage points". Obligatory passage points have various functions: They resemble knots in a network that are indispensable for the practice of acting in concert. They constitute material connections between various practices or legitimate intellectual reference points in debates. Why are obligatory passage points so influential, and how are they different from boundary objects? Schumpeter's understanding of monopolies is helpful here as it sheds light on the nature of obligatory passage points. To begin with, one has to recall a fundamental aspect of capitalism that Marx and Schumpeter emphasized: economic development is a nonlinear and unpredictable process. Especially for Schumpeter, the endless stream of innovations is the actual engine of capitalism—to quote from him at length:

> "The first thing to be noticed about the capitalist process is its evolutionary character. Stationary socialism would still be socialism but stationary capitalism is impossible, is, in fact, a contradiction in terms. For the central figure on the capitalist stage, the entrepreneur (q.v.), is concerned not with the administration of existing industrial plant and equipment but with the incessant creation of new plant and equipment, embodying new technologies that revolutionize existing industrial structures. This is the source of his profits (…) All the typical phenomena of capitalism, all its achievements, problems and vicissitudes, including the trade cycle (q.v.), derive from this process." (Schumpeter 1946, pp. 198-199)

This raises a difficult question: if creative destruction never stops revolutionizing "the economic structure *from within*" (Schumpeter 1943, p. 83) how can we conceive of structures, that is, stable relations as possible outcome at all? Schumpeter's answer lies in the discussion of "monopolies". He holds that innovations typically lead to monopolies if only in a temporal manner. According to Schumpeter, non-perfect competition has to be viewed as desirable outcome.[175] So, against overactive anti-trust proponents, Schumpeter argued that temporary monopolies are a necessary condition for entrepreneurs to accept the huge risks of investing in innovations. By and large, the realization of temporal monopolies keeps the capitalist process running (Schumpeter 1947, pp. 87ff). The market might be structured in favor of a single company that possesses superior procedures or radically novel products.

The empirical record shows that monopolies end rather earlier than later. Because further innovations tend to denigrate a company's advantage and legal rights, such as

[175] While the opposite view that innovations are stopped by monopolies and, more recently, by protective patenting, has been raised ever since the turn of the last century (Gagnon 2009, Moldaschl and Stehr 2010), a holistic view on the historical record proofs Schumpeter's understanding correct. Partial monopolies have not hampered the increased pace of innovations after World War II (Archibugi and Michie 1997, Diamond 2006).

patents, expire anyway. In practice, a company usually exploits its monopoly only for a certain period, argues Schumpeter (1943, p. 99), as a new cycle of innovations may destroy the existing monopoly or render it meaningless (Spencer and Kirchhoff 2006). In addition, Schumpeter points out that the emergence of short-term "monopolies" as a result of creative destruction can't be assessed in a static setting because the innovative firms "provide the necessary form for the achievement" in the first place: "they largely create what they exploit." (Schumpeter 1943, p. 101) The obligatory passage point in an assemblage roughly resembles the Schumpeterian idea of a temporal monopoly.

Insights from innovation economics also help to distinguish between boundary objects and obligatory passage points more clearly. Boundary objects possess the particular *technical* capacity to connect—the term authority, here, can refer to this ability. So, while actors have different choices during ongoing controversies, over a period of time, boundary objects assemble more and more actors and thus turn into proto-monopolies. At a certain point (marked by a dotted line in figure 9.1), pragmatic activities are routinized so that few alternative ways of assembling with respect to the initial concern or thing is thinkable and tangible. In a stable assemblage, one or several obligatory passage points frame decisions, practices, and artificial objects according to their fixed set of standards or a single script.

It is in this sense, that "monopolies" do not merely denote an asymmetric moment of control or possession of certain goods, ideas, products or technologies. Monopolizing actors constitute an *intersection* of relations within or across assemblage. All new actors that are enrolled—say in an *ideal typing* "market assemblage"—have to pass through this point and stay related with it subsequently. Such a prominent, if temporary, structural position is a result of technological innovations. Authority, to put it differently, has turned into the ability to structure the options of other human and non-human actors to assemble.[176] The shift from authority to structural influence is akin to the first mover advantage that puts certain innovators[177] in the best position to exploit the fruits their

[176] Furthermore, monopolizing actors are influencing the associating activities of other actors and may enjoy the additional advantage of creating further obligatory passage points—while increasing the size of an assemblage.

[177] This does not apply to all innovators.

work by harnessing the new forms of acting in concert, which had not existed before a specific assemblage was stabilized.

However, this economic-inspired reading of the third phase of translations is not sufficient to comprehend all effects of stabilization. The phase of translation is also finalized by fixing the level of onto-politics. After major controversies are settled and the "outpouring" matters of concern had been transformed into black boxes, a new order or knowledge has been established. A hegemonic episteme regulates both epistemology and ontology. Thus, the experience within a stable assemblage includes fixed delimitations about which actors and agencies, ontologically speaking, belong to an assemblage and the particular limits of political discourse of what knowledge is real, ultimate, and legitimate are clearly shaped and enforced by standardized ways of knowing (cf. Foucault 2005).

A last component that is important to keep an assemblage together is the "immutable mobiles" (see Chapter 8). For instance, as European monarchies and companies established a vast "global network of communications" between the fifteenth and the eighteenth centuries, (Braudel 1992a, p. 415, McNeill and McNeill 2003), printed texts became critical elements in these fragile networks. The movement of these "fixed inscriptions" containing new knowledge and information about the outside world was a decisive factor to assemble land, resources and people. The advantage of mobile, accurate knowledge available to conquistador Pizzaro is exemplified by the events after he had arrived in Peru in 1527. Before this singular encounter of two great powers from different continents, the Inca rulers had neither learned about the landing of Spanish ships at American shores several decades earlier, nor were they informed about the brutal conquest of other powerful native societies by Spanish soldiers. Pizzaro, on the other hand, knew the reports from fellow conquistadores and thus was able to make informed judgments about his enemies' whereabouts and behavior.

The capture (and later execution) of Inca Emperor Atahualpa in the year 1532, a furious achievement of a completely outnumbered troop of Spaniards, was published in book form back in Spain only nine months after the incident happened (Diamond 1999, pp. 69ff).[178] Secret reports, maps, resource inventories, classifications of plants and animals, ships' logs and so forth increasingly circulated back and forth, thus enabling people at the "centers of calculation"—that is, where Lisbon, Madrid, Paris and later London were located—to know, to archive and to recombine what they had never seen with their own eyes. In brief, the combination of centers of calculation mobile inscriptions made it possible to rule "at a distance" over a diversity of peoples, lands, and natural resources (Latour 1987, p. 219); it had never been realized before, a long time before the invention of the telegraph, radio, satellites and the Internet.

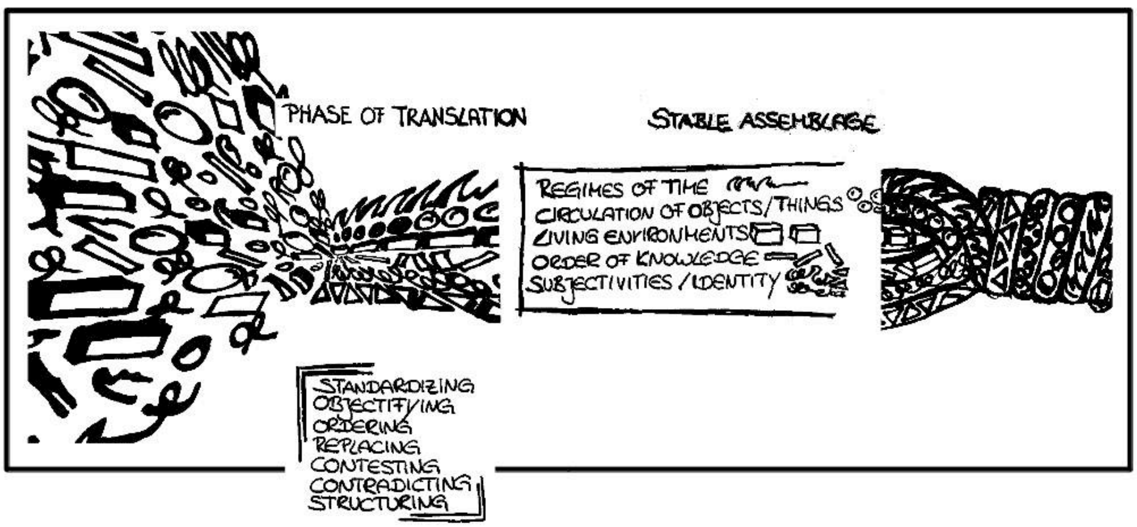


FIGURE 9.2 ASSEMBLING ©AUTHOR

By now, the puzzle of stability becomes fully intelligible. As indicated in figure 9.1, the stability of assemblages stems from the correlation between two factors. On the one hand, the size of an assemblage, referring to the number and diversity of assembled actors (y-axis); on the other hand, the end of the translation phase, which is plotted as a temporal dimension along the x-axis. A stable state is reached when the red curve, which illustrates the evolution of an association in figure 9.1, reaches the upper right quadrant.

In addition to the abstract evolution model, figure 9.2 shows the full effects of stabilization by articulating more in detail the three layers of figure 9.1. This rendering,

[178] This account is far from comprehensive. Especially, it must be pointed out here that female translators played a central role in giving the Spaniards the advantage to know their enemies much better than vice versa (Todorov 1982).

then, depicts the dimensionality of the assembling process which is generative of a regime of time, build environments, specific objects of circulation and particular subjectivities all of which have been stabilized at the end of the phase of translation. It is important to notice that these dimensions have a post-Cartesian quality. They are neither based on dichotomies juxtaposing the "social" and "material", nor do they signify combinations of "socio-technical" entities. Instead, regimes of time, for instance, always combine materials, practices, and discourses. Similarly, "orders of knowledge" are not only constructed by cognitive categories but also enabled by material and technical forms of knowledge storage, research methods, and data processing. As a result, stable assemblages have a specific and enduring order of knowledge in which both "facts" and the range of possible "truth claims" are fixed.

At this point, it is worth digging deeper into the "order of knowledge" (or what was earlier called "epistemological hegemony") that has evolved through translation; especially, the question arises how to better understand the (hidden) effects of assembling. Each order of knowledge implies a certain politics of ignorance. According to a particular onto-political commitment some things are "matters of concern" while others are taken as "matters of fact" (see Chapter 8). Cascades of translations allowed for the acceptance of certain practices and institutional apparatuses that might seem, from outside of an assemblages, odd or ridiculous and would otherwise inspire resistance. Consequently, their ramifications are naturalized in accordance with a certain epistemic hegemony. Naturalization is ubiquitous. For example, consider that we knowingly accept the high death toll from traffic, the environmental pollution resulting from war, or the civilian casualties from "precision" drone warfare.

This orchestrated silence, which could be referred to as "externalities" or "collateral damage", is strongly related to the stability and instability of assemblages. On the one side, the scope of relevant political issues that warrant attention is limited. The politics of ignorance is specific for each assemblage. In this sense, the term "black-boxes" signifies silent actors. The intermediaries that are readily connecting and smoothly circulating without disruptions differ between assemblages. Notwithstanding "real" tradeoffs which are deemed unavoidable, the questioning of or resistance against that what had been naturalized (yet renders an assemblage stable) is not a legitimate action. On the other side, this silence can be reversed as the discussion of forms of technological agency in Chapter 8 has shown. The emergence of new "matters of concern" renders established practices controversial, and makes the epistemological hegemony potentially fragile.

Ulrich Beck's *Risk Society* and subsequent works illuminate the politics of non-knowledge. Beck studied how "modernity" had to take into account the side-effects of technological progress. The "silence" and non-knowledge became a precarious and destabilizing factor in a constantly modernizing society. Chemical substances or technical devices turned into a matter of grave concern ranging from the (previously unknown) toxic nature of construction materials, the dangers of new scientifically produced substances, or the detrimental effects of large-scale infrastructures and industrial pollution (Beck 1986, Beck, Bonss and Lau 2003). Nevertheless, it can be generally assumed that many things are necessarily black-boxed and externalized in a stable assemblage—despite the chance of opening black boxes.

Having explored the process of assembling, the effect of technological innovations became clear. According the idea of creative destruction, technological innovations are generative power via the emergence of a collective that acts in concert. In sum, this process was mapped in three phases: technological innovations start with unconnected collectors (innovating actors), turn to a phase of boundary objects, and, finally, crystallize through obligatory passage points. If one follows the expanding size of an assemblage (y-axis in figure 9.1) over decades or even centuries, its own ontological parameters become apparent (See Graham 2016b). In particular, in the case of an extremely large association the new reality entails, among other things, new regimes of time and space, new build environments and new life styles, imaginaries and so on.

9.2 Reassembling

From the claim that assemblages are generative of their own modes of reality does not follow that every attempt to assemble will result in a new, full-fledged assemblage. The reason is that only few innovating actors achieve this goal (and many do not have such a goal). The authoritative ability to assemble differs from innovator to innovator and so does the novelty of proposed connections. The understanding that innovative activities are often less ambitious and that not all innovations are equally transformative brings us to the second model of creative destruction: reassembling. What are the differences between assembling and reassembling? The key point is how different types of technological innovations relate to the magnitude of shifts in power and authority as a consequence of translation.[179] In other words, while reassembling also involves a phase of translation, the latter is typically short, less controversial and far less wide-ranging.

To compare "radical" and "incremental" technological innovations offers a relatively simple and useful distinction.[180] I employ the concepts of radical and incremental innovation in the following sense:[181] *Radical innovations* refer to the assembling that has no substantial prior connection to existing assemblages and all practices that keep them stable – a "thing" becomes a matter of concern at the start of the evolution of an assemblage (see figure 9.1), which is radically alien to known materials and practices within existing assemblages. Radical innovations therefore are the product of an extremely creative vision and a very strong authority of an innovator. In addition, radical innovation such as the automobile, the bicycle or the use of electricity often need a longer time to materialize than incremental innovations because their radically new properties require a high degree of translations.

The best way to illustrate the problem of radical novelty, which is often mentioned with reference to Schumpeter's idea of innovation (see Spencer and Kirchhoff 2006), are the many cases in which inventors successfully assembled an invention but came, nonetheless, too "early" because no further connections with the surrounding assemblages could be forged. As such, the balloon invented by the famous Montgolfier brothers that flew with passengers in the year 1784 remained a fairly exotic and "useless" phenomenon. Flying became "possible" only 130 years later, when an array of radical innovations finally ushered the air age. The fate of being too early is shared by many inventions. Another way to illuminate the difficulties of radical innovations is to observe

[179] The occurrence of reassembling can have different reasons. As noted above, the assembling process can lead to reassembling in existing assemblages. When increasingly more actors are enrolled elsewhere other assemblages are affected by controversies, must realign themselves, or can even break into pieces (see Latour 2005, Whatmore 2009).

[180] In addition, I will also discuss the relative as opposed to the absolute novelty of technological innovations and which translational steps they require.

[181] For a discussion see Chapter 7.

the mismatches between their potential demands on the one side, and the actually existing mental, regulative, and material support infrastructures on the other side. Consider the case of the automobile. In the early 20th century, the number of cars often grew much faster than the existing system of expressways and urban streets but also traffic laws, driver experience, and public awareness could accommodate.

The power that results from radical innovations is immense. Drawing on Schumpeter, the logic of (temporal) monopolies can be used to distinguish between assembling and reassembling. "Generic technologies" such as microelectronics are an example of radical innovations. They "apply to almost and industry" and are so pervasive that their rise is facilitated by the creation not only new companies, industries, and markets but also a novel technological paradigm (Russell 1997, Dosi 1988). Radical innovations, therefore, always involve new boundary objects and obligatory passage points, thus, resulting in a translation process of assembling to the detriment of other "knots" as was discussed above. As assembling radical innovations requires an enormous authority to construct seamless webs and to enroll actors into relations, it leads to completely unanticipated and unprecedented connections generating vast monopolies which is untypical for reassembling. For instance, a firm that comes to dominate entire business sectors, or the imperial capitals in Europe that gradually became able to govern "empires" or "world markets" across vast distances (cf. Schumpeter 1943, p. 117).

The term "radical", however, implies an exaggeration, as it has to refer to the complex settings of innovational processes. Firstly, even radically novel inventions have to build on material components, concepts, engineering know-how, or scientific insights that do already exist. Rarely are these components created or produced at the same time.[182] Secondly, radical innovations require other existing assemblages to adopt – and thus tend to lead to reassembling. Renewable energy sources such as wind and solar power, surely embodying radical technological innovations, exemplify the legal, technical, political, financial, and technological challenges to plug into larger existing networks of electricity production and consumption. Notwithstanding a radical break is impossible, the electricity networks have to be reconfigured in myriad ways to adapt to

[182] Arguably, this was the case with the Manhattan project that had to pioneer entire industrial processes, special metals, and other materials to be capable of manufacturing the first atomic bomb at all.

solar roof panels, small scale power plants or the unstable power production of large wind parks and so on. Thirdly, the term radical innovations also can signify relative novelty--novelty as compared to the surrounding assemblages. Although a specific innovation might not be "new to the world" viewed from a global perspective, it still constitutes a radical novel development, say, in a certain region, area, or environment (see Ayres 1985).

For example, the technological innovations brought to the Arctic regions or to Southern Mongolian mining areas in order to start extracting natural riches such as oil, gas, iron ore, copper, and gold count as radical innovations in a relative sense. For the ongoing assembling has significant consequences to other prior existing assemblages such as indigenous ways of living, working, energy use, or agriculture. The same is true for the radical impacts that new road-systems and pipelines, which are build to connect South Asia from Iran to India, or for the water power dams constructed in pristine mountain valleys in western China[183]—these technological innovations, thus, share in common that they alter regimes of space and time in a fundamental manner at the local level.

In contrast, *incremental innovations* refer to technical artifacts, technological systems and infrastructures, or other elements that are purposefully constructed to fit into existing assemblages and practices. This type of innovation, thus, does not face the difficulties of "too early" inventions. Usually, it does not lead to the emergence of new collectives and obligatory passage points but rather to the reshuffling and enlargement of preexisting assemblages. Still, the power effects of reassembling can be immense. The reason that incremental innovations have strong power effects is because they enable assemblages, following the logic of path-dependency, to recruit more or other actors.[184]

[183] About mining in Mongolia see Gillet (2012). About recent construction work on pipelines and road system in Eurasia see Escobar (2012). On dams in china see Phillips (2012).

[184] Numerous processes of reassembling unfold on a global scale, including the spread of "isotopes" (Herran and Roque 2009), the establishment of pasteurization (Latour 1988), organic chemistry (Hugill and Bachmann 2005), the usage of containers (Poulsen 2007, Mutlu 2015), the proliferation of mobile communication tools (Castells 2007) and the usage of "bloggs" (Drezner 2010).

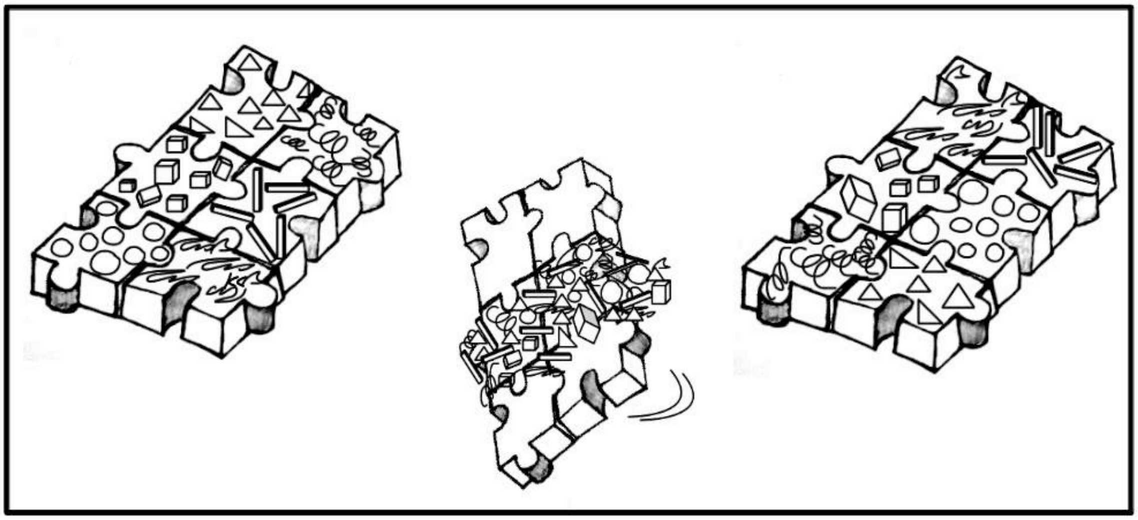


FIGURE 9.3 REASSEMBLING ©AUTHOR

Incremental innovations are related to reassembling as figure 9.3 illustrates. In a process of reassembling, obligatory passage points are not totally replaced. The process tends to cement the monopole positions that are already occupied. In brief, comparing these (stylized) accounts of incremental and radical innovations shows that both can lead to power shifts. The key difference is that radical innovations require numerous translations and are authority-intensive. The authority, in contrast, that is necessary to reassemble due to incremental innovations is smaller than in the case of radical innovations. For enrolling more intermediaries and black boxes proceeds with fewer controversies as the "order or knowledge" remains stable. Radical innovations possess the tendency to create new obligatory passage points and generate new realities. The incremental innovations can fortify existing monopolies or shift both authority and obligatory passage point, while the modes of reality largely remain unaltered.

Reassembling also includes cumulative and interactive dynamics. Through creating multiple and interconnected layers of temporal monopolies—some will expire soon, others are persisting due to constant flow of various technological innovations—creative destruction leads to massive shifts in power. The contemporary world cannot be thought without the great assemblages of the final decades of the nineteenth century—electricity grids, radio signals, railways, and cable based inter-continental telecommunication—that have fundamentally altered "acting in concert" on a planetary scale (Smil 2005, see

Buzan and Lawson 2015). There is no way around the obligatory passage points of these assemblages and the convergence of many of the involved technologies. In this line, one could argue that these collectives, by creating radically different regimes of time and space, embodied the power that fundamentally set apart the "West" and the rest of the world after around 1830.[185] This observation corresponds with the nineteenth-century experiences of Japanese and Iranians. In their eyes, the key difference of the European or Western colonial powers was the "machine civilization" that underpinned their thinking and acting (Mirsepassi 2004, p. 104, Wakabayashi 1986).

The example of the "petroleum assemblage" shows the cumulative dynamics of reassembling. After the assemblage emerged from a few radical innovations, a long process of reassembling set in. The first drilling efforts were in the late 1870s and the fossil fuel production for transport really started only after the year 1905. Through incremental innovations new actors are enrolled such as kerosene lamps, combustion engines chemical products, ships, cars, and so on, thereby increasing the size of assemblage by magnitudes. Today, even after two "oils shocks", the popularization of "peak oil" and the danger of fossil emissions, petroleum still features as the "life blood" of our civilization (Yergin 1991). The powerful reality of this assemblage is operating as countries like China, Vietnam and India became fully fossil societies. Reassembling is akin to a path-dependency on the technical and intellectual level.[186]

Susan Strange's and Joseph Nye's emphasis on the structural persistence of US hegemony refers to the same idea. Due to prior investments in large technical systems, aspiring powers are typically confronted with the difficulty of reshaping global infrastructures of transport, energy, and communication in their own favor (Strange 1989, Nye and Owens 1996, Krige et al. 2013).

"The one country that can best lead the information revolution will be more powerful than

[185] However, it is not convincing to presume a determining force of technological path-dependency, which prolongs the technological superiority of an actor indefinitely. The history of technological innovations shows a frequent sharing of knowledge, unexpected combination, or exchange of agency among humans and non-humans.

[186] The reality of multifaceted oil-dependency is still purely understood. Political, economic, engineering and scientific commitments prohibit an alternative imagination, that is, how we could reasonably overcome this predicament—a condition that is not fully comprehended with regard to international politics (Mitchell 2011, Litfin 2003).

> any other. For the foreseeable future, that country is the United States. (…) This advantage stems from Cold War investments and America's open society, thanks to which it dominates important communications and information processing technologies – space-based surveillance, direct broadcasting, high-speed computers – and has an unparalleled ability to integrate complex information systems". (Nye and Owens 1996, pp. 20ff.)

Existing layers of technologies form a complex landscape that assigns an asymmetric position to different actors (Below et al. 2014). Chang (2002) and May (2009) point out how these asymmetric "knowledge structures" inhibited the economic ascent of developing nations, prefiguring the growth of their national innovative capacities. The uneven distribution of infrastructural power constitutes a highly politicized issue in international politics (Krasner 1991, Arrighi 1994). A broader view suggests that the obligatory passage points within assemblages of global communication systems, transport infrastructures, weather monitoring, and research laboratories result from earlier standard-setting and administrative and legal decisions. There was an earlier process of assembling that promoted international regulations and binding rules as dominant states have tried to extend domestic regulations beyond their borders (see Kindleberger 1988, Howland 2014). More recently, technological leaders shaped the global regulations of intellectual property rights (IPR) under which expertise, products and techniques are transferred in their favor (Singleton 2008, p. 200). For instance, the EU and US, argues Andre Sapir, are "the regulators of the world" as they account for around eighty percent of norms and standards that regulate world markets (2007, p. x). As such, the current global intellectual property system reflects the preferences of the industrial countries in general and those of multinational corporations in particular (Wissen 2003, Sell 2003, Matthews 2002).

In contrast to its cumulative effect, the process of reassembling can also lead to a demise of authority and the replacement of monopolies. The evolution of the "rubber assemblage" illuminates how authority can shift. To begin with, this resource assemblage materialized with the advent of bicycles, automobiles, and several other applications in industrializing countries, which produced an enormous demand for crude rubber (Knorr 1945, p. 9). For decades, the main source for supply was wild rubber, which was collected in tropical forests. Brazil enjoyed a monopoly over rubber exports making Latin

America the home of the world's richest rubber barons. Their operations placed certain Amazonian regions at the center of a rapidly growing global rubber assemblage which also included the US companies such as Dunlop and Goodyear as well as millions of automobile and bicycle users worldwide. But the association was destabilized by further innovations. The relocation of rubber trees and the construction of rubber plantations in South East Asia by commercial pioneers began to redraw the connections within the rubber network. During the First World War, the plantations in Siam and British Malaysia became the obligatory passage point of a reassembled association producing more than 90 percent of the total global rubber output. As had happened earlier in Latin America, the production and export of raw materials led to an expansion of asymmetric wealth while local state-assemblages and market assemblages became technologically linked and globally interdependent—by shipping and railway systems but also through the movement of plants, people, and animal species (Kennedy and Lucks 1999, Knorr 1945).

Then another wave of reassembling occurred. German scientists pioneered methods to synthetically produce rubber. Subsequently, they became innovators that worked hard to reassemble yet again the rubber assemblage, shifting the monopole position. In the late 1930s, German and US firms powerfully assembled a "synthetic rubber assemblage". They constructed this new network through scientific and engineering innovations, new chemical particles and national security concerns. Germany had been cut off from rubber supplies in the First and Second World Wars and the US had the same experience during the Pacific War (Hugill and Bachmann 2005). After 1945, petrochemical companies became obligatory passage points, feeding the growing demand for synthetic rubber as well as other chemical products (Chapman 1992).[187] Though natural rubber still has a considerable market share, by the late 1960s, synthetic production accounted for roughly 60 percent of industrial rubber (Wellhausen and Mukunda 2009, p. 119). As a result, neither Brazilian rubber barons, nor East Indian plantations functioned as obligatory passage points.[188] In the Tropical areas, the plantations, the laborers, the rubber trees, and

[187] Technological innovations, particularly the synthetic production of various raw materials by the rising chemical industries had considerable impacts on tropical production networks, wealth distribution, and under-development (Hugill 1988, Wellhausen and Mukunda 2009).

[188] The economic consequences of these power and authority shifts can be seen, for example, in the case of Argentina. At the turn of the 19th century, it was among the global top five wealthy countries; "civilized"

the related national economies, which by now were involved in the production of "natural" rubber, experienced a significant decrease of authority, but they remained assembled. In the reassembled rubber collective, in addition, the ontology of rubber was different and also the scientific knowledge related to rubber production.

In sum, reassembling involves the shift of authority and can lead to the enrollment of new actors or, in contrast, to decline of an association. The process of reassembling often is coupled to a process of assembling elsewhere and, thus, implies a certain level of interconnectivity and synchronicity that is studied – using a different vocabulary – in the literature about "uneven and combined development" (cf. Rosenberg 2010). The crucial difference to assembling, though, is that even when reassembling does result in the remodeled and reframed character of an assemblage, it does not lead to a complete change of the stabilized dimensions of reality, as it happens to be the case with disassembling.

9.3 Disassembling

While we have examined technological innovations through the lenses of assembling and reassembling, the final model of creative destruction is the most radical. At the core of disassembling lies a massive loss of power, that is, the decreasing ability of numerous actors to act in concert within an assemblage. The ability of assemblages to "glue" actors together declines sharply. As a result, practices become controversial, obligatory passage points "degenerate" to mere boundary objects and descend into obscurity. Under conditions of disassembling, monopoly positions become insignificant. At the most fundamental level, a loss of power signals the decreasing ability of an assemblage to be generative of a distinct mode of reality. The destructive process, therefore, can be seen as reversing the three phases of translation depicted in figure 9.1.

In extreme cases, collectives cease to exist as a consequence of disassembling. The experiences related to this shift are powerful and stunning. Creative destruction renders disappearing seemingly vast assemblages such as, for example, large companies,

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on par with European nations. However, after the First World War it rapidly lost, related to shifts the production and trade in raw materials, its favorable economic conditions (Campante and Glaeser 2009).

industrial sectors and resource supply chains, countries, empires—or, at it were, the mighty knights and with them the feudal order of medieval Europe (see McNeill 1982, pp. 33ff.). Conceptually, this process refers to the vanishing of an entire reality. The order of knowledge, the regime of time, built environments, the circulations of artificial objects, and personal subjectivities that were enmeshed in practices, discourses, and material agencies are dissolved. As figure 9.4 illustrates, disassembling does resemble a mirror image of assembling.

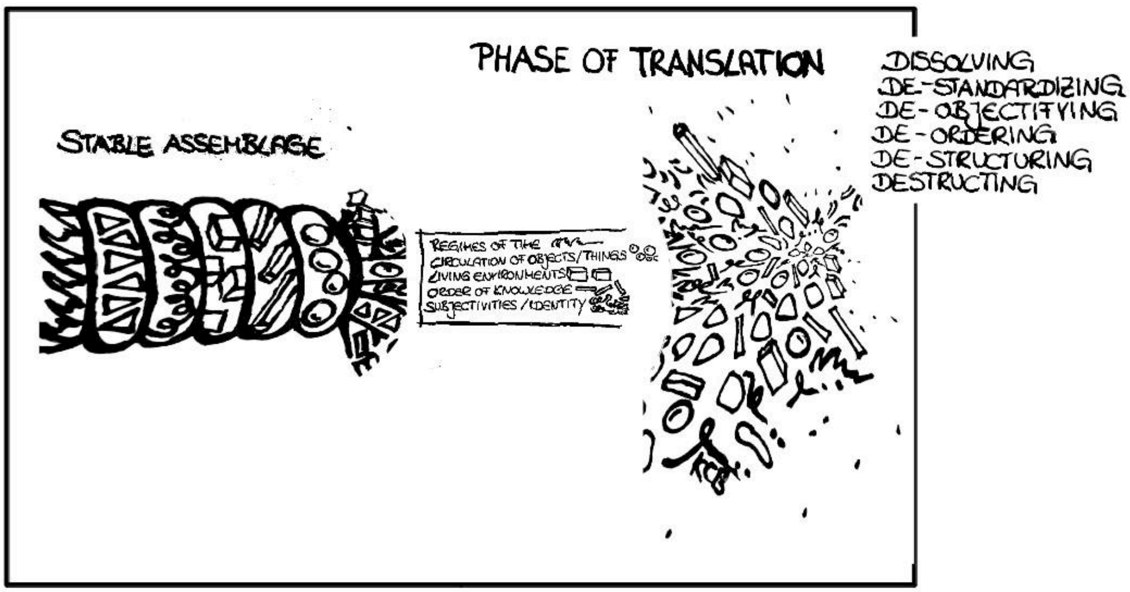

FIGURE 9.4 DISASSEMBLING ©AUTHOR

As such, the idea of "ruination" offers an interesting way to conceptualize the dissolution of assemblages. The awareness of structures and monuments, especially from the great empires of the past, is well developed in the trope of "ruin gazing" in Europe (Stoler 2008, Hell and Schönle 2010). The size of ancient assemblages can still be captured if one cultivates the ability to read the historical landscape through ruins. For example, the ruined castles that everywhere are littered across Europe suggest that vastness of the "Feudal assemblage". Elsewhere, industrial ruins are a prominent example of technological transformations that have led to the destruction of entire local and regional economies and lifestyles (Mah 2012).

Another crucial aspect of the decrease of power in an assemblage is the loss of practical knowledge. While the material substance of the built environment may remain in place with more or less endurance, the knowledge how artifacts such as the Egyptian pyramids or the Cathedrals of the Middle Age were constructed is lost. Disassembling undoes technologies and the knowledge how to construct them as numerous examples show. Consider the engineering capabilities of the ancient Greeks, the medicine of Arabic doctors, the abilities for road-construction, sewage systems, or weapon technologies in Roman Empire, the imperial Chinese activities of drilling, shipbuilding, or watch-making that have been forgotten. More contemporaneous examples include traditional manufacturing skills to produce silk, clothes, or carpets that have vanished with the globalization of monocultures of industrial manufacturing (cf. Mittelman 2004). Some observers worry that the IT technologies of the digital age ultimately erase the hard-earned ability of handwriting in the Western world (Goff 2008). To sum up, the process of disassembling dismantles technologies and, thereby, also destroys the know-how to build, employ, and maintain them.

This disturbing effect of disassembling is a pressing real-world concern related to various high technologies that are part of our energy collectives. It regards, for example, the considerably intractable question of how the storage places for radioactive waste should be designed to endure millennia: a problem that enjoys an alarming low degree of attention (Hora and von Winterfeld 1997, Alvarez 2012). Moreover, disassembling could be used purposefully in order to "uninvent" nuclear weapons as MacKenzie and Spinardi argue. These systems could be disintegrated including all relevant know-how, tacit knowledge, and industrial processes (MacKenzie and Spinardi 1995).

The major problem to describe the process of disassembling lies in the proverbial insight that "history is written by the victors". The reason that it is so difficult to capture disassembling processes is because the politics of ignorance of other assemblages, described above, makes disassembling almost invisible. The decreasing ability to "act in concert", it needs to be noted again, is often closely related to the emergence of radical innovations elsewhere, which lead to replacements in one assemblage and erosion of connections and agencies in another assemblage. Moreover, certain actors may get enrolled in a new assemblage while no longer participating in their previous actor-network. Against this background, the new epistemological hegemony has a double effect: first, it silences practices that are no longer matters of concern. Second, it also silences the historical narratives and the experience related to the assemblage that disintegrates. So, while assembling might bring about new realities of time, space, and subjectivities, at the heard of disassembling lies the erosion and *eradication* of these very realities.

After an assemblage dissolved it can become impossible to remember it or even unbelievable that such an assemblage had actually existed at all. The novel *One Hundred Years of Solitude* is a superb exemplification of the limits of memory. Not unlike other Latin American writers, Colombian author Gabriel García Márquez captures the magic and the tragedy of an entire life cycle of collectives—embodied in the mythic village Macondo—from assembling to its total dissolution. In his fabulous story, several generations of the family Buendía perform the role of innovators. Numerous technological innovations (coming from the outside of the village) reassemble their village. From its poor origins, the village eventually becomes related to the political struggles in Colombia and the global commodity markets (García 1967). The most important feature, as far as our discussion is concerned, is García's concern for the problem of keeping the memory of events and the entire world of the village alive. The concern for remembering is woven throughout his masterful story. The village Macondo, in the end, vanishes without any traces of its material existence.

That the history of Macondo, its people and the human experiences that were vital to its success disappear is suggestive.[189] García's story narrates the eradicative implications of "disassembling" that remain a formidable theoretical and empirical challenge. One element of his account is the lack of frame of references after a mode of reality was obliterated. The notion of creative destruction, in this sense, renders intelligible what it means if the evolution of assemblages entails incommensurable realities. It is difficult to keep the description of incommensurable assemblages next to each other at all. For example, Buzan and Lawson (2015, pp. 166ff.) suggest in their discussion of the transformation during the nineteenth century that the experience of time was radically different for people in the core as compared to people living at the

[189] See Martin (1989, chapt. 7) and Ortega (2010) for a thorough discussion of *One Hundred Years of Solitude.*

periphery of the world system. The magnitude and the direction of changes come down to different, almost incommensurable, experiences as suggested by the notion of era versus the experience of a spatial and temporal break with the past.

Finally, the resemblance between disassembling and warfare needs to be clarified. Whereas violence cannot sustain assembling, the destructive aspects of technological innovations sometime can equal the consequences of military conflict. Obviously, violent conquest can destabilize existing networks. The employment of the British, Dutch, Portuguese and French naval forces, for instance, led to a reconfiguration of trading routes and political alliances in the Indian Ocean region during the seventeenth and eighteenth centuries (cf. Frank 1996, p. 62). Warfare can destroy a state assemblage or an economic network. This is highlighted by the wars destroying the assemblage of Imperial Japan in 1945 as well as the multi-ethnic empire ruled by the House of Habsburg or the Ottoman empire by end of World War I. But the cases of disassembling by war are a minority.

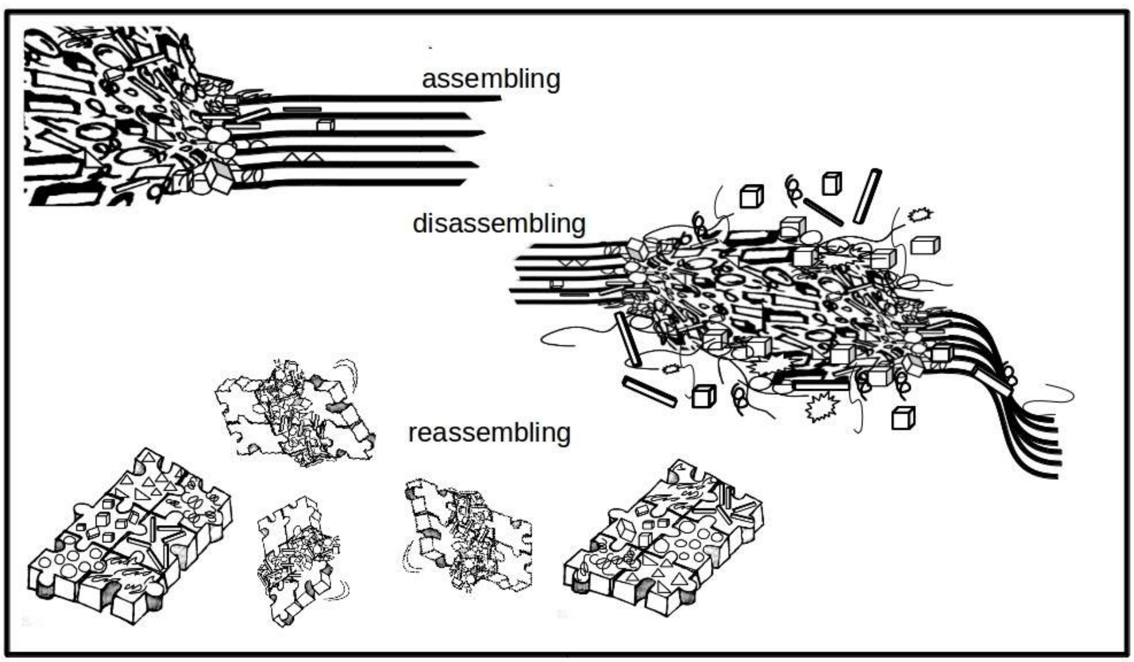

FIGURE 9.5 VARIETIES OF CREATIVE CONSTRUCTION IN COMPARISON ©AUTHOR

For we find few empirical cases where all former practices, relations, connections, and obligatory passage points, which were integral components of a large assemblage, were pulverized by warfare. Overall, war has a limited ability to disassemble simply for the reason that “state assemblages” and other large assemblages are constituted by psychological, material, and technological agencies, among many other aspects, which can endure every conceivable defeat. However, another case of disassembling involves violent practices. The most radical examples are the operations of settler colonialism. It has been pointed out that the form of “dissembling” pursued by settler colonial societies deliberately targets lifestyles, time, memory, knowledge, build environments, and so forth. The ultimate goal of physical, structural and institutional violence is the destruction of an entire collective and its very mode of existence (Wolfe 2006, Veracini 2011). In sum, creative destruction mainly involves violent and non-violent processes of disassembling.

Assemblages can completely vanish even without violence as exemplified by the resource assemblage that formed around whaling. Worldwide, fishermen and small processing companies used to secure the global fuel supply of lamps and lightening, aside from producing the raw materials for many additional products based on whaling. Yet as kerosene and, later, electrical light bulbs were invented, new collectives, which emerged through kerosene production and use, replaced the whaling assemblage in the late 1870s. Although that Epstein does not apply the vocabulary of assemblages, her study on the discourse of whaling offers a brilliant case of disassembling; a process unfolding on a global level in which local traditions and economies, the various products obtained from the whale hunt, and the culture of whaling completely disappeared (Epstein 2008, cf. Yergin 1991).

9.4 Summary

The three process models of creative destruction expand the conceptual toolbox of IR. Summarizing the main ideas of this chapter, figure 9.5 offers a schematic depiction comparing the three models of creative destruction. In addition, table 9.6 provides the analytical vocabulary that helps distinguishing between assembling, reassembling, and disassembling. Conceptualizing technological innovations as the emergence, reconfiguration, and destruction of assemblages offer various puzzles and sites, scaling up and down within and across assemblages, to explore technological innovations in a coherent and comparative way even though these processes in situ often overlap, are interlinked, or evolve in parallel.

forms of creative destruction	**types of technological innovation**	**power-effects in assemblages**	**vocabulary metaphors for the phase of translation**
assembling	radical innovations	collective creation of power new ideal-typing assemblages, new topological assemblages	assembling enrolling recruiting collecting connecting aligning objectifying, constructing building designing ordering framing
reassembling	radical and incremental innovations	shifts in power and authority alterations in existing ideal-typing assemblages and topologies	reassembling reconfiguring reframing reshuffling reorganizing reforming restructuring replacing transforming remaking
disassembling	radical innovations	existential loss of power and authority	disassembling dissolving de-standardizing de-objectifying de-stabilizing de-framing de-ordering destructing de-linking

TABLE 9.6 THE VOCABULARIES OF CREATIVE DESTRUCTION ©AUTHOR

While assembling follows an evolutionary path of stabilization (see figure 9.1) the "destructive" side of creative destruction can equally be analyzed in three phases of translation—but in a reversed order, starting with a stable assemblage. Disassembling comprises, for example, controversies that call into question established practices or the ways in which actors are related. The ability to act in concert is diminished. In brief, technological innovations, both incremental and radical in nature, can lead to the destruction of an assemblage, resulting in an unrelated multiplicity while a new assemblage emerges elsewhere. Disassembling implies the de-framing, de-standardizing, de-objectifying, and dissolving of assemblages, which amounts to the destabilization of the entire mode of reality.

Reassembling involves shifts in authority and obligatory passage points without immediately breaking apart an assemblage. Yet it is still destabilizing to the extent to which a collective slides (back) into a phase of translation. Routines become challenged and black boxes are re-opened. Some actors increase their ability to enroll others and become more important nodes. Others, in contrast, face a decreasing authority. The monopole positions of certain actors erode, whereas new innovators are able to assemble more actors.

It has become clear that the enormous power effects encapsulated in the third model of creative destruction concerns the disruption of the fundamental dimensions human life such as space, time, knowledge, and subjectivity. Decreasing or destroying the ability of "acting in concert"—within an assemblage—constitutes the most elementary and, arguably, most underappreciated effect of technological innovations. The moving of ontological and epistemic parameters makes technological innovations and, particularly, radical innovations unique and powerful processes. Moreover, technological innovations are special because, while many collectives have not primarily been the result of technological innovations in the first place, creative destruction potentially can destabilize any assemblage. In sum, the notion of creative destruction treats human and non-human actors symmetrically and conceptualizes assembling, reassembling and disassembling as three distinct processes of coproduction. Such a post-Cartesian approach to technological innovations might contribute to overcoming the "lightness" of IR.

10. Conclusion: a plea for leaving the pond

In 1949, William Fielding Ogburn introduced the first extensive edited volume about "Technology and International Relations", noting that the subject matter "is one in which there has not been much scientific research." The "field of technology and international relations", Ogburn claimed, were "pioneering ventures." (Ogburn 1949, p. vi) Ogburn would be surprised to discover that the subject matter still remains in a pioneering phase. Although a growing number of researchers advance the issue and a new section has been established in the International Studies Association, neither a technology related subfield nor a specific research agenda or debate is established thus far. Chapter 4 detailed how IR scholarship, with few exceptions, neglected the myriad technologies and non-human agencies that influence world politics. Two modes of thought, the social-reductionist and the externalizing, that prevail within IR scholarship have marginalized technological innovations, particularly as an object for theorizing.

This makes technological innovations an intriguing topic. They resemble, I propose, an Archimedean point from which we can assess the broader achievements and limitations of the entire discipline. What lessons can be derived from the fate of technological innovations within IR? Are they simply too unpredictable for systemic theories to deal with? Do the academic blindfolds, which are responsible for the omission of technologies, perhaps, constitute a sort of Achilles' heel of theorizing global politics? The neglect of technological innovation does not merely result from a lack of curiosity or coincidental moves on the conceptual level. It is rather, as Chapter 4 and 5 elaborate, the result of the "Cartesian complex" – the foundational commitment that renders IR an almost entirely *social* science that deliberately excludes non-humans, materials artifacts, technologies, and hybrid modes of agency. As the "foundational" debates in IR were mostly preoccupied with the intricacies of epistemology, the logocentric bias has remained largely unaddressed, legitimizing the discipline's generic *lightness*. The rise of Foucauldian approaches, new materialism, and other similar figures of though have only recently begun to dispute the logocentrism of IR.

Overcoming the rampant logocentrism with a dose of explorative realism perhaps constitutes an iconoclastic attitude of sorts. Taking an explorative realist methodology pushes one into a somewhat radical position. But I believe that our discipline should give up its lightness. The practice that parsimoniously depicts and conceptualizes the world, as if materials, artifacts, and technological agencies were inexistent is untenable. Because of technologically mediated global problems abound such as climate change, urbanization, and energy security, but also as nano-technologies, big data and robotics emerge at the nexus of warfare, statehood and technological networks, we should give up the dualistic parsimony and treacherous simplicity that is prevalent in research practice and theoretical concepts. In this vein, the following conclusions reflect upon three critical issues intimately related to the main outcomes of my study: the ethos of cosmopolitics, the promise of ontological expansion, and the design of post-Cartesian research puzzles.

10.1 The cosmopolitics of creative destruction

In order to overcome the lightness of IR theories, this book shed light on world politics by introducing the vocabulary of *assemblages* and *creative destruction*. While both notions enable a symmetrical conceptualization of technological innovations, creative destruction also can function as a metaphor that enables us to appreciate the politics of technological innovations in specific ways as "cosmopolitics". To begin with, cosmopolitarian approaches refer to a reality that is mingled, fluid, interconnected and prone to massive changes; an understanding that appreciates classical "modern" thinkers such as Johann Wolfgang von Goethe, Jean-Jacques Rousseau, and Karl Marx (cf. Berman 2010). The term cosmopolitics captures both the evolution of a specific assemblage *and* the combination of all assemblages—connected, overlapping, competing, or unrelated. It accepts humans alongside with non-human actors in a single conceptual domain, or rather a multiplicity that does neither possess a common regime of time or space, nor a separation between the "social" and the "material".

Normatively, this view sets one apart, for example, from Aristotelian and Platonic imaginations of representational politics. While examining the onto-political commitments of IR theories I connected the ideas of such thinkers as Hannah Arendt, Joseph Schumpeter, Cythia Enloe, Karl Marx, James Der Derian, Michel Callon, Annemarie Mol or Bruno Latour, amongst others. Their insights, indeed, lead us to reexamine recent articulations of liberal cosmopolitanism and post-structural frameworks that miss to situate political communities according to their evolving spatial, temporal, and technological dimensions (e.g. Jakobeit, Kappel, and Mückenberger 2010, Beck 2004, Pogge 2008, Archibugi 2008, Chandler 2009). As such, these approaches articulate a purely social science: they perpetuate and reify the matter-mind distinction and the premises of a dualist ontology. I agree with Linklater that "the central question is whether humans can undergo a global 'civilizing process' in which the widening of the 'scope of emotional identification' keeps pace with any further lengthening of the webs of material interconnectedness" (Linklater, 2010, p. 156). Alternatives are necessary that are based on a heterogeneous ontology. Without the principle of symmetry any understanding of "cosmopolitics" is challenged by technological innovations (Latour 2004a, 2011).

Post-Cartesian ethics, in brief, amount to a *relative understanding of the dimensions constitutive of reality*—a reality under composition, which can be called 'cosmos'. This view bears no resemblance to "postmodern" structuralism (cf. Stenger 1997, Latour 2004b). Instead, this approach emphasizes ruptures, non-linearity, unintended consequences, and feedbacks that affect all dimensions of reality as a major research topic. Non-dualistic premises are particularly apt for IR as we face rapid changes in world politics tied to emerging technological innovations. While similar conditions were to a certain degree present in earlier phases, contemporary dynamics render the stabilization of collectives more difficult than ever. Creative destruction as a metaphor then conveys a crucial lesson. When grasping the essence of "politics", one should avoid references to static and dualist constellations, a priori fixed sets of actors and interactions. In short, the main research concern focuses on the themes of stabilization, becoming and emergence.

A cosmopolitarian research practice also requires a new analytical-methodical language. To this end, I suggest an ensemble of analytical terms that are deliberately "blank" to enable the discovery of new things and relations. The flat ontology that is implied by the concept of actor-networks aims at overcoming the meta-theoretical shortcomings of static notions such as the "international system" or "levels of analysis". It replaces bipolar narratives such as "micro-macro" and "structure-agency" with empirically founded understandings of processes of assembling and a relational understanding of agency, not limited to human actors. Theorizing technological innovations becomes easier if concepts such as “institutions” and “structures” are abandoned for the time being. Because of their contemporary usage the latter terms inevitably carry a logocentric burden and forestall the development of a post-Cartesian approach to world politics.[190]

Furthermore, the notions of “power” and “authority” were reframed in order to make sense of the effects and processes of assembling, reassembling and disassembling. The term “power” has come to signify “acting in concert”, referring to an entire assemblage. It is no longer located within individual (social) actors or invisible structures. Power, in addition, captures the coproductive consequences of a *stabilized* assemblage: a fixed temporality, subjectivity, and build environments among other things. For instance, the petroleum assemblage involves life-styles, commercial interests, forms of war and traffic, physical and chemical changes in the atmosphere, and so on. “Authority”, on the other hand, means the capability of assembling other actors into one collective. It denotes a creative ability—necessary for both incremental and radical innovations—of single actors to forge connections and construct seamless networks. Technological innovations resemble a process of assembling but they also involve the destabilization or even dissolution of previously existing assemblages. Both sides of creative destruction lead to significant shifts in power and authority. Their analysis highlights the centrality of various non-coercive forms of power in global affairs and the need for a sophisticated exploration thereof.

What are the politics at stake with technological innovations that theoretical approaches and research practice has to cope with? Three aspects are central to the cosmopolitics of creative destruction.

Reality confronts us with a *multiplicity of agency*. This requires open and evolving classifications instead of an order-imposing mono-typologies and fixed taxonomies. Research equates ontological expansion and its practice isn’t guided by foregrounding epistemological concerns. Concealing the materiality of its subject matters, on the

[190] One can still employ generic IR “containers” such as states, transnational companies, organizations or regimes. However, this requires a conceptual refashioning in accordance with the notion of *assemblages* and always needs to refer to actor-networks entailing human and non-human agency.

contrary, would only remove IR further from real-world problems. Ontological realism replaces the reductionist twin-brothers techno-determinism and social instrumentalism. Against the current onto-politics of IR, the principle of symmetry offers sensibilities towards the beings and agencies of things, processes, entities, humans, and nonhumans alike.

Technological innovations involve the construction of new assemblages while reconfiguring existing collectives. These processes imply a certain imbalance between silence and concern. In turn, researchers should carefully study controversies and black boxes in order to uncover historical and contemporary silences. Through interrogating the totality of a given reality, this kind of cosmopolitics counteracts the politics of ignorance inherent in the evolution of assemblages. Exploring silenced externalities brings to the fore the full "costs" of stabilizing an assemblage. As research depicts the externalized effects of innovations, it problematizes "matter of facts" and collapses the difference between "facts" and "values". The state of non-differentiation is necessary because we often simply do not know how numerous and diverse the actors and agencies are, especially in large assemblages. Epistemology, in a first step, then comes down to the concern for having accounted for all relevant actors and relations. This imperative, which plays out in the methodological position of limbo, certainly should not be mistaken with a certain ethical stance that grants political and legal rights to objects – the ontological and political level are separated.

The power of assemblages lies in their ability to enroll and relate a decreasing and increasing number of actors in stabilized practices. The stability of any assemblage involves more dimensions and aspects than social theories tend to make us believe. I suggest probing into different mechanisms of stabilization such as the normalization of practices, the stabilization of facts, obligatory passage points, and a hegemonic episteme. Yet, the collective power is contingent. Almighty associations can become destabilized, even beginning from marginal positions. That assemblages are not totalities enables resistance. If time, space, subjectivities and so on are not constants but contingent stabilizations, which spring form the power effects of assemblages, framing alternative futures is always possible even the most powerful assemblages.[191] The contingence of power, thus understood, enables one to see better what world one "sings into existence" (Smith 2004), as we use our own authority to assemble in manifold transformative ways. Cosmopolitics, in brief, means that researchers have to reconsider their own interventions in contributing to stabilization and destabilization (Aradau and Huysmans 2010).

This stance, however, does not suggest that the way in which this study theorizes innovations is indicative of a specific political program. My choice of vocabulary does not imply ideological bias for or against technological progress. It remains for the readers to draw their own conclusions. I am not subscribing to the praise of capitalist peace dividends (Weede 2004, Schumpeter 1919). My usage of the concept of "creative destruction" does not promote the goal of international technological primacy akin to the Cold War's arms race. Nor am I necessarily writing in defense of criticisms against "neoliberalism" (Harvey 2007). Yet I have highlighted the often-violent reality of creative destruction and various negative effects of technological innovations that are often overseen or conceptually brushed aside (Sveiby, Gripenberg, and Segercrantz 2012).

To conclude, the central task of research is *describing the multiplicity of life* that is reshuffled through creative destruction. Instead of "telling the truth"—or deconstructing truth—as Cartesian traditions demand, we rather have to painstakingly *report and archive* reality (cf. Foote 1990). The task of accounting for respective processes of translations can be disturbing and controversial. Although this does not lead to abandoning Descartes' idea of "analysis" entirely (see Chapter 6), attempts at classifying must therefore remain open-ended, as a matter of principle. Explorative realism is also critical ethical approach. Cosmopolitics, in sum, require re-representing the multitude of complex agencies and embedded modes of existence as the various collectives in which we live.

10.2 Ontological expansion is promising for the discipline of IR

Despite its neglect of a technologically transformed world, IR seemingly thrives well

[191] With Jacques Rancière (2008) one can emphasize the centrality of the marginal actors, the ambivalence of existence and agency, and the contestations over group membership.

within its confines. The numbers of students interested in international studies and global politics, as Chris Brown (2007) highlights, are constantly rising. Isn't it outright implausible that the disciplinary framework could be so mistaken? The reluctance against radical theoretical inventions is reasonable. And yet, summarizing the outcomes of interrogating IR and technological innovations leads to precisely this conclusion. On a positive note, we might acknowledge the relatively young age of IR—compared with Theology, Law, Philosophy or Physics. If the discipline is approaching "adolescence", perhaps, we had better tolerate weird twists and non-conformist attitudes for good. However, this metaphor misses a crucial point. On a more sober note, we have to recognize that many of the basic premises and conceptual notions that commonly underpin mainstream schools of thought, guide research, and frame policy advocacy are murky. In spite of the widening reach of approaches to IR and multi-perspectivism abound ever since the third "great debate" (Lapit 1989, Holsti 1985a, Wendt 1999, Jackson 2011), core notions still retain a shaky empirical substance and have an under-reflected genealogy.

Against this backdrop, this book contributes to ongoing reflections about the building blocks of IR theory.[192] The attempt to explore technological innovations—conceptually and empirically—places the premises and presuppositions on which the Cartesian framework is based under sustained meta-theoretical and historical scrutiny. In particular, I took issue with a fundamental limitation of IR theory. IR theories are in a state of denial about the fact that material objects and hybrid associations of humans and non-humans vitally mediate between almost all conceivable agencies and certainly between those agencies meaningful to world politics. Consequently, I have argued in favor of expanding ontological parameters, suggesting a post-Cartesian matrix. Making sense of technological innovations—and other subject matters—demands treating process and agency as empirical questions; not as a priori given conceptual demarcations or theoretical or logical puzzles.

[192] Several landmark studies began to seriously tackle the elephants in the room. These works interrogate common and mostly unquestioned notions such as "state", "anarchy", the "state of nature", "the Westphalian system", "the international system", or "sovereignty". See Ashley (1984), Walker (1991), Jahn (1999), Krasner (1999), Shaw (2004), Ossiander (2001), Vaughan-Williams (2009), and Sampson (2002).

Overcoming the logocentric state-of-the-art has several positive effects. For one, it will arguably render IR much more relevant to the actual concerns of different sorts of people and collectives. Carrying its insights far beyond its narrow domain, IR could thereby move out of the largely irrelevant position that it holds in public debates today (Buzan and Little 2001). The remodeling of research concerns should enables us to speak with a different voice and to many more and different sorts of publics and peoples (cf. Lawson 2008). For another, the expansion of ontological parameters enables IR researchers to close ranks with fellow colleagues in the neighboring disciplines, many of which have been exploring the multiplicity of material worlds along the "environmental borderlands" for a long time (Zimmerer 2007). The list comprises history, sociology, geography, science studies, post-colonial, subaltern, and area studies, ethnology, gender studies, world system approaches, and so on. Is it too far-fetched to envision a form of interdisciplinary collaboration through which we learn from the immensely rich insights of our peers? Tapping into their knowledge would catapult IR scholarship forward, because it could learn from various meta-theoretical debates that had been settled in other disciplines long ago. Indeed, much of the knowledge that is relevant to reframe central premises and notions of IR theories could come from other disciplines (e.g. Scott 1998, Alonso 1994, Carroll 2006, Mitchell 2002).

In this sense, explorative realism favors an empirical benchmarking for theories and puzzles. Just as physics refers to mathematical theorems and the accumulated knowledge of other "natural sciences", social science can improve its validation of knowledge claims. One important step is to overcome the self-inflicted disciplinary compartmentalization. Our self-contained concepts such as the "state", then, would be brought into conversation with different bodies of empirical knowledge in anthropology, geography and science studies. If external sources become a legitimate or even required empirical reference point, then they do no longer constitute a "threat" from the outside.[193] As a result, IR might turn from a concept-importer—dependent on "external" epistemic communities for conceptual supplies (Brown 2007, p. 350)—into a net-exporter of

[193] As a side effect, IR would not just overcome its identity-fixation. Freed from its "mythical" ritualism (Sterling-Folker 2006) and turning inter-disciplinary exchanges from a taboo into a practical necessity, it would arguably become more scientific.

theoretical notions and analytical puzzles.

At the moment, what particularly makes various standard premises and concepts untenable is the Cartesian onto-political order, which they impose on our subject matters, while reinforcing inherent logocentric limitations—limitations that are both more extreme and implausible than most scholars would admit. As Bruno Latour reminds us,

> "to study is always to do politics in the sense that it collects or composes what the common world is made of. The delicate question is to decide what sort of collection and what sort of composition is needed… We claim that the controversies about what types of stuff make up the social world should not be solved by social scientists, but should be resumed by future participants and that at every moment the 'package' making up existing social links should be opened for public scrutiny. This means the two tasks of taking into account and putting into order have to be kept separate." (Latour 2005, p. 257)

To exemplify the *explorative function* of theory this study has laid out "creative destruction" and "assemblages" as a conceptual toolbox to navigate an offshore venture into post-Cartesian seas. The former resembles a foundational collector, an analytical concept as close to research practice as possible, while the latter is a conceptual model. However, putting forward a few new theoretical concepts does not suffice. The exploration of technological innovations rather demands a new foundational map. To guide orientation, obviously, this map must have distinctly post-Cartesian characteristics. Otherwise it would lead us into the shallow waters of dualism, which this explorative realist examination scrutinized and rejected.

First of all, it claims that simply rebalancing material and ideal "factors" in a more appropriate manner is not enough. For a core issue at stake is exactly the increasing hybridization and intermingling of human and non-human agencies. At the fortunate confluence of a conversation gesturing towards post-Cartesianism (Wendt 2015, Poliout 2010) on the one side, and a lively debate about materialism on the other, this study offers a contribution to both developments: it proposes a monist understanding that allows for multiple ontologies though, while a new meta-theoretical matrix renders intelligible what this means for IR theories. The "double-mixed zone", particularly, is suited to support ontological expansion as it embraces processes of emergence and heterogeneous agencies in particular. This move implies, on the one hand, moving from a concern with stability to a concern with stabilization. On the other hand, it invokes a relativist paradigm for IR, which avoids treating time, space, knowledge, artificial objects, and built environments as constants. Such a relativist commitment, then, opens up new empirical issues and concerns as well as radically different theoretical puzzles.

Secondly, figures, graphs and other visual depictions of our subject matters are of central importance for ontological expansion; especially, because a poverty of pictures, images, and figures underpins logo-centric confusion (Mayer forthcoming). The lack of illustrations and framings in general and the reductionist nature of the existing examples in particular are also representative for the "lightness" of IR theories. In sum, IR as a discipline has failed to develop an imaginative depiction of our puzzles and theoretical concepts. Explorative realism offers an important clue in this regard. As the subject-object distinction concerning both the status of our knowledge and our research practice collapses (Chapter 6), we are intractably entangled with the subject matters of our research. This leads, as science studies have shown, to mutual influences throughout a process of co-construction. In this sense, the importance of figurations cannot be over-estimated with respect to capturing the "heavy side" of world politics. We must notice that when we inquire technological innovations, the materials, in turn, work their way into our research practices and theoretical frameworks through imaginative images, graphs and figures. It is thus paramount to proactively generate more of these boundary objects.

Thirdly, explorative realism de-emphasizes epistemological infighting. At its core lies a shift towards methodological humbleness—working in the limbo of non-knowledge. It appreciates observing and describing a reality full of fluid processes and contested agencies, which constitutes a challenge much bigger than inferring anemic models of causality or debating epistemological monocultures. Moving beyond epistemological debates is highly relevant, as I believe that the most pressing concern for our discipline lies in *finding new research puzzles* that make sense at all. In expanding our ontological parameters, we should put considerable efforts into the exploration of "post-international" concerns. Cynthia Enloe argues that examining human trafficking is not just ethically warranted. This issue commands our attention because it also contains unknown or neglected aspects crucial to "international politics" (Enloe 2000, p. XI ff.).

While not writing for an IR audience, Mark Pendergrast's (2010) history of coffee or Mazan Labban (2008) and Gavin Brigde's (2008) work on fossil resources exemplify the same appraoch. To support empirical research on global transformations and processes of emergence this book proposed a set of conceptual tools to locate and systematize cases, puzzles, and scales in relation to assemblages. Three open-ended classifications and three models of creative destruction enable the mapping of magnitudes of translations, changing size and topologies, altering scripts, and shifting power and authority in assemblages.

10.3 Discovering post-Cartesian research puzzles

By extension, the implications for future research are briefly outlined by five puzzles that illustrate the novel landscapes becoming accessible and intelligible for IR scholars. To take material agencies seriously while exploring multiple assemblages results in alternative research objects investigated within the framework of (a refashioned) IR. *Making Things International* demonstrates how different artifacts and technologies can be studied via assemblages without totally abandoning the "international" as an organizing frame as (Salter 2015). As such, to study assemblages by accounting for some "masses" is crucial:

It might be an assemblage consisting of statistical calculations, geometry, tunnels, drainage systems, highways, battleships, newspapers, history museums, surveillance drones, school curricula, clinics, universities, sniffer dogs, border walls, ethnic identity, official currencies, television programs, paved streets, music and uniforms, electronic voting machines, asylum camps, concrete, emigration practices, concentration camps, police officers, railway bandwidths, prison cells, leisure parks, body scanners, standard time zones, flags, asphalt, great fire walls … or simply what is conventionally seen as "nation state".

It could be an assemblage of concrete, wire, cars, spouses, security personnel, bars, bargaining psychology, first class lounges, bribery, video communication networks, maidens, satellites, track-two meetings, air travel, telephones, translations and mistranslations, immunity, coffee, conference hotels, spies, prostitutes, cultural institutes, *conspiracies and deception, exposed embassy cables, hasty press conferences, prime ministers, drunken or with jet-leg ... or simply what is conventionally treated as "international diplomacy".*

Or, we explore a rather different assemblage, entailing formula one car racing, gas stations, US solders protecting Iraqi oil-pipelines, rich Arabic sheiks in Davos and imprisoned Russian oligarchs, tanker fleets, expanding pipeline networks, boy toys, petro-dollars, ocean drilling, crushed EV1s, Dutch diseases, State Oils conflict with fisher communities in the far north of Norway, Chinese engineers in Sudan and Gabon, national energy balance sheets, oil theft in Nigeria and corruption scandals in France, rigs and ruined landscapes, the mathematics of petroleum reserves, abiotic theories of oil, the OPEC, oil platforms, the American Automobile Association campaigning, fuel price-manipulations, large harbors, energy security formula, climate skeptics and disclosure tricks in environmental assessments, peak-oil fears, mass auto-mobilization in India and Vietnam, ... or simply what we would coin "hydrocarbon associations".

Building on such an exploration of assemblages, the next step, then, is probing into the creative destruction arising from technological innovations as detailed in Chapter 9. The following puzzles, referring to the three models of assembling, reassembling, and disassembling, are suggestive of various further research puzzles:

Creative destruction and cyborg warfare: One might explore the assembling through which new types of digital and autonomous weapons systems and digital-algorithmic infrastructures create a powerful new collective that fundamentally alters the reality we live in. This translation does not go without major controversies. The autonomous warfare, for instance, redraws the boundaries between war and peace: homeland and foreign turf, civilian and combatant, law and the arbitrariness of making law unilaterally, "sovereignty" and "justice" collapse (DeLanda 1991, Barkawi 2011). While these issues have been raised separately elsewhere, this puzzle poses the ontological question as to how creative destruction turns military assemblages into a novel war machine while destabilizing various other assemblages. For example, the web of drone technology, satellite data, and intelligence enables the US president to personally order killing attacks and "signature strikes" (Becker and Shane 2012), facilitating a systematical undermining of the practice of sovereignty and international law. Innovations in network-centered warfare also remodel the "soldier". He/she/it becomes a cyborg warrior, physically and mentally connected with technological automats and embedded in virtually simulated realities. Increasingly, non-human actors such as drones and robots acquire a prominent position as boundary objects in security practices and war theaters. Non-human actors even tend to become obligatory passage points within the emerging cyber-world in which humans are eclipsed from decision-making and no longer at the center of carrying out the globally extended security operations (Singer 2009, Der Derian 2009, Lee 2012). How does creative destruction relate to the collapse of the distinction between war and peace of which IR discourses are also part? To begin with, how have we as a discipline arrived at a point where we fail to challenge mass slaughter and legitimize so called high-precision weapons while silencing that surgical strikes cause so many civilian casualties (Bergen and Tiedemann 2011)? Why have we fallen short calling for a stop or even a ban of drones and droning? How is the cyborgization of military practices related to the "epistemic mutations" that have altered the meaning of war, soldiers, attacks, civilians, sovereignty and international law? What does this imply for people living in places and in bodies assembled through cyborg warfare (Holmquist 2013)? What are the consequences of novel spatial concepts such as "ungoverned territories" that decisively pulverize sovereignty in the context of cyborg-warfare (Schetter 2012)? How much authority shifts away from human-dominated classical platforms (such as fighter jets and artillery), towards hybrid or purely autonomous practices of fighting? In sum, this puzzle explores how creative destruction is fundamentally transforming the reality of warfare and entire scales of world politics therewith.

Stabilizing time and the "great divergence": We might reframe the puzzle of "great divergence" and the great asymmetries of power in he world by inquiring the construction of time and space. This implies not to take time and space for granted as constants but to explore their construction, especially looking at the nineteenth and early twentieth century. The creation of a global standard time may explain to a large extent why the power differentials between European empires and several other political assemblages could shift so rapidly between 1800 and 1850 (Hom 2010). But it remains largely unclear how much innovations including technical, political, philosophical, scientific, and economic efforts, have assembled and stabilized a world standard time that has been kept stable until today. Historians and anthropologists have started this inquiry (Harvey 1989, Galison 2006, Kern 2003, Nanni 2012). But many questions remain untouched. What agencies were involved in these innovational processes? What role does "objective science" play in stabilizing imperial outreach (MacLoed 1993, Pyenson 1993)? What are the obligatory passage points in this assemblage and where lie its silences (see Watts 1983)? In this line, Hutchings proposes the idea of 'heterotemporality'. With it she challenges IR and wants to 'undermine the idea that we can theorise world-political time in homogeneous or unified terms' (Hutchings 2008, p. 155). Explorations as these, more generally speaking, are concerned with the shifting topology of assemblages. The true meaning of the term "great divergence", consequently, is much more radical than a common understanding that a bunch of "economic", "institutional" and "technical" factors account for the unlikely "rise of the West". Highlighting creative destruction instead renders the fundamental chasms between emerging, often incommensurable realities tangible, which are experienced by many, for instance analyzing the nexus of modern development and so-called "environmental conflict" critically (e.g. Dalby 2002, Duffield 2006). This puzzle, in sum, pushes the reconstruction of "Western" monocultures of time to the center of theorizing in IR. Such a move entails an ethical and analytical stance towards global politics that keeps "time" fundamentally open as suggested by reflexive realism (Hom and Steele 2010).

Technological innovations and state formation: We might take on a somewhat related puzzle yet involving a longer historic period in exploring the formation of modern states as a process of assembling. Against the prevailing attitude in IR that takes "states" by and large as given this involves probing into various technological innovations that enabled assembling "the state" (Rose and Miller 1992, Sassen 2000, Passoth and Rowland 2010). The huge material world of artifacts, systems and technologies is under-researched—including for instance maps and cartography (Mitchell 2002, Branch 2011), the printing press and newspapers (Anderson 1996). In addition, as modern statehood requires navigational instruments, clocks, it was affected by the circulation of new scientific methods and collected "things" from the Americans (Barrera-Osorio 2010). How does the extension of complex material infrastructures, for example, change territorial organization on a regional and global level (Duara 2006, Swyngedouw 2008)? How is the inside/outside of sovereignty enabled by divided temporalities (Alonso 1994, Weber 1998)? Today, as technological innovations evolve relentlessly, what shifts of power and authority take place within state assemblages (Castells 2008)? While new collectives were assembled through innovations such as the mobile phone, renewable energy technologies, deep sea drilling, hydraulic fracturing, the World Wide Web, social media, and digital technologies, how does this reconfigure processes of "state formation"? Do these innovations merely reassemble state assemblages, or, conversely, is a complete dissolution or replacement of state assemblages thinkable? From another angle, we could explore the technologically dominated assemblages such as metropolitan areas and "global cities", questioning the living conditions they provide for humans, animals and plants at the one hand, and tracing the links to international diplomacy, financial accumulation, and global governance on the other (Brenner 1998, Coward 2012, Acuto 2013, Farías and Bender 2010, Sassen 2002).

Assembling, disassembling, and "resource colonization": A perspective of assemblages also sheds fresh light on colonization and decolonization. For example, how were the material remnants such as infrastructures, borders, and buildings of imperial assemblages reassembled? By mapping the topologies of resources, assemblages might show an astonishing continuance of networks and obligatory passage points over centuries that render the phenomenon of "weak states" intelligible (e.g. Roberts and Parks 2007) or highlight the "new wars" from a material angle. Such a cartography would also call into question the practice of UN units and NGOs in former colonies in the sense that the fact that they work along these assemblages perpetuates a politics of expertise that puts a premium on "good governance" and "social" institutions without recognizing the very technological condition of state formation (Schouten 2013). In specific ways, this challenges the World Bank's stylized puzzles of development research and blue prints alike. Furthermore, it challenges the theoretical and conceptual paucity that silences the actual relationship between "underdevelopment" and the practices of long-standing resource assemblages (see Bunker 1984). Unearthing this nexus on the one hand ties into Foucauldian accounts of colonialism focusing on the ideal-typing assemblages (Viswanathan and Said 1993, Mbembé and Steven Rendall 2000). On the other hand, going beyond the ethnology of scripted practices, it is required to inquire into the topologies of material assemblages. These seem the most unknown and under-explored subject matters to me. However, at the same time they are utmost ubiquitous in our daily lives. In any way, IR should contribute to making transparent, in a symmetrical way, what is assembled in the vast resource assemblages: It should break with the omission of the former's external effects and the controversies concerning almost every single resource assemblage (Peluso and Watts 2001, Shiva 1994). With explorative realism, IR is leaving its comfort zone of scientific monocultures to follow the fuels, raw materials, minerals, drugs, and food supplies.

Rapid climate change and the construction of the arctic region: The rapid physical and political changes in the Arctic call for a probe into the construction of a "regional assemblage" (McKie 2012). The prospect of shortening the sea-lanes between Europe and Asia by up to 4,000 nautical miles destabilizes the existing sovereignty practices concerning borders, navigation, defense, and extraction (Gerhardt, Steinberg, Tasch, Fabiano, and Shields 2010). The Canadian government is rapidly extending its military presence at the American continent's northern rim in order to control its exposed territorial demarcations. On the opposite side of the Arctic, Russia's government is trying to secure territorial claims and the interests of its national oil companies by re-establishing its strategic "bear bombers", patrols and large-scale military drills (Mayer 2012a, pp. 173ff.). While the rapid changes are portrayed as threats to national sovereignty (Borgerson 2008), the technological agency that enables the assembling of people, resources, water, and weather into new regional collectives is understudied. The focus on strategic rivalries silences the fate of indigenous groups—not to mention that of flora and fauna. Indigenous populations become marginalized despite the fact that their livelihood is existentially threatened (Leichenko and O'Brien 2008, pp. 91-103, Adger, Barnett, Chapin, and Ellemor 2011, pp. 9-13). The rapid "opening up" of the Arctic resembles the construction of a region in the most fundamental sense as it involves the emergence and inter-linkage of several heterogeneous assemblages. Despite conflicting strategic interests, the governments of Denmark, Russia, and Canada agreed to solve their territorial disputes within international legal frameworks. Additionally, scientific practices and technological innovations occupy central roles: Geologists' and lawyers' mapping the region's continental shelves shall ascertain which nations own exclusive rights to exploit the potential large gas and oil deposits under International Law (Mayer and Schouten 2012, p. 25). Furthermore, legions of engineers, geologists, and geographers explore the region's actual carbon resources and develop new drilling technologies fit for extreme climatic conditions. The manner in which various ideal-typing and topological assemblages overlap and are connected to actor-networks of transport, shipping, and fossil resource extraction provides an extraordinary case for the study of region building. Not the least, this is also a seminal instance to test alternative designs of "inclusive" global governance (Mayer and Arndt 2012, Long Martello 2008).

These five puzzles indicate possible attempts to overcome the "lightness" of IR. Of course, there are many more research directions tackling the challenge of a post-Cartesian mode of research. This requires, first, collaboration across disciplines to which few are accustomed in IR and social sciences at large. The complexity and global reach of the empirical materials also posits a formidable challenge to the language skills, fieldwork abilities, and the intercultural capacities of the researchers.[194] Secondly, these post-Cartesian puzzles exemplify a sort of theoretical perspective that is incompatible with instrumentalist and the state-centric ideas about the role of technologies in global politics.

As explorative realism holds, IR is first of all responsible for a solid *reporting* of reality without convenient reductionisms. Nothing less. This is a much more formidable task than realizing the imperative of "parsimony" has ever been. Against compartmentalization and purification, post-Cartesian puzzles do not only have an added value in terms of improving our comprehension of global politics. Some might ask whether this is really relevant for policy making? The answer to this question is negative—if one believes that "policy relevance" refers to simply reproducing, reifying, or envisioning the "nation state" and the "international system" whatever these two terms may signify. Instead, I want to turn this question on its head. What is the value of "heavy" IR puzzles other than the lesson that the conventional manner of conceptualizing "policy" itself is by and large irrelevant, at least, with respect to the reality of

[194] In this line, pragmatist approaches to philosophy of science, although praising the eclectic use of theoretical IR perspectives (e.g. Sil and Katzenstein 2010), appear not well aware of practical and methodological tasks that go way beyond the disciplinary confines of IR.

technological innovations? For instance, it has become obvious why concerns with top-down state-led strategies are anachronistic. Management, policy making or research designs that build on a control and command model of innovation is doomed to fail because creative destruction evolves in the context of various assemblages and is conditioned by shifting agencies between humans, artificial objects or some mix of both.

10.4 Setting sails

At the beginning of this book, I told the story of a Fishermen village. The inhabitants lived at the coast; yet they had never tried fishing offshore. At the risk of oversimplification, this metaphor points to the epistemic community of IR as it increasingly realizes the limited confines of its domain. Barry Buzan's verdict that IR has failed as an intellectual project demands important qualifications. This book tries to account for the reasons of this predicament. Alternative paths must rest on a clear understanding of the meta-theoretical commitments that led our discipline to accept and legitimize a "small pond" in the first place. So why should we hedge this narrow domain? Why not venture out into the uncharted blue waters? One of my goals precisely was stimulating a conversion among those, who are interested in "offshore" strategies. Inquiring into technological innovations and material agency presents a particularly promising direction for a post-Cartesian IR agenda. The lesson from recent developments in history suggests that such an agenda, not at least, would also enhance the agenda of globalizing IR. For while history is in a metamorphosis and increasingly turns to writing a truly global history, the research about things, materials, and technologies plays a crucial role therein.[195]

Every expansion is welcome. The current situation, which is seen as a crisis by many, ought not to lead to premature foreclosures. Rather, the recent onto-political inroads are but the beginning. It is reasonable to expect further extensions of what counts as legitimate fields/areas/sets of subject matters in IR. I agree with Peter T. Jackson that it is definitely too early to restrict the discipline's ontological scope, although this

[195] See Appadurai (1996), Bayly (2003), McNeill and McNeill (2003), Auslander (2005) and the exchanges in the 2009 issue of the *American Historical Review* (pp. 1355-1404).

constitutes a routine practice of constructivist and neorealist projects (Jackson 2011). In this regard, a comparison with other scientific disciplines is illuminating. IR is about a hundred years old. Compared, say with Physics, Chemistry, or Theology, it owns but a short biography. In other words, we are in the early stages of our development and, should thus anticipate further barriers to building our epistemic identity. If Kuhn's insights apply to IR we should welcome this foundational insecurity. Perhaps, ontological expansion is more a process of centuries than of decades, as it is the case with Physics that has never stopped expanding its ontological parameters. In accordance to the non-normal condition of our discipline, "theories" performing an explorative mode play a key role. Debating our foundations should no longer be driven by the anxiety to get bereft of the status of science—nor by an "inferiority complex" as Susan Strange (1988, p.12) has pointed out. Instead, a comparison with other disciplines reveals that the number of "objects" and "processes" that is theoretically embodied by the framework of IR—not to mention the number of sets (of sets) of objects and processes—is still very limited.

Strong pull factors notwithstanding, why does IR scholarship stubbornly shy away from leaving behind narrow theoretical routines? Why is it so hard to convince ourselves to set sails? Perhaps, we are tied down by the deep-seated fear inherited from the "founding fathers", many of whom have believed that it is only through a clear demarcation as well as a unique subject matter that IR could become a respected discipline of its own (Williams 2005, Guilhot 2011)? Arguably, by abandoning the pond that has provisioned us with a secure delimitation, we risk dissolving our discipline. This possibility cannot be ruled out indeed. As such, potential epistemic competitors as "world system theory", "global governance" or "international political economy" are signs on the wall. These strong research fields could strip off the best minds and vital funding from IR. Should we not simply stick to the pond in order to save the discipline of "International Relations"? Or, conversely, do we have to replace "IR" with an alternative master concept and another set of foundational notions and premises? Frankly, I think there is no need to come up with an answer to these questions at the present. The establishment of a fresh vocabulary for "IR" is less vital than our engagement with empirical multiplicity.

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