CHAPTER ONE

THINKING ABOUT TECHNOLOGY AND INTERNATIONAL POLITICS

In the late fifteenth century the French king recruited Swiss mercenaries to strengthen his armies. Unlike the horse-dependent French noblemen the king often coerced into fighting for him, the Swiss were infantrymen armed with pikes or long spears. The soldiers' battle technique was especially formidable against a mounted knight, and their introduction on European battlefields tilted the advantage away from horsemen and toward massed infantry. Socially and politically, the Swiss pikemen contributed to the shift from the feudal social system from which the knight drew his power and position and toward states and other large military–political organizations that were capable of building and maintaining large armies.[1] The pike did not end feudalism, but its introduction was necessary for the premodern to modern transformation.[2]

The Swiss mercenaries were agents of change to the international system. They were carriers of knowledge and skills that for centuries had served effectively for cantonal defense at home. European states transformed the Swiss practice into an important new military technology—the modern army of pike and gun. Mastery of this new technology was essential to Maurice of Nassau in the sixteenth and seventeenth centuries, who, despite the small resources of the United Provinces, kept the northern part of the Low Countries free from French and Spanish rule. It was also critical in King Gustavus Adolphus of Sweden's spectacular military feats during the Thirty Years' War. But the successful introduction of the modern army did more than just enable Holland and Sweden to gain international prominence and power—it transformed the nature of the international system and the states that constituted it.

Yet the pike, the object, is only the beginning of the story of technology and system transformation. More important were the institutions, social practices, and politics surrounding it and giving it political (and military) meaning. The pike was embedded within one set of social institutions (Swiss security practices). It was rethought and reshaped by a different set of social actors (European states). The French king recruited the Swiss because he sought an advantage over his Spanish rivals. He was engaging in balancing behavior, one of the central mechanisms of international political systems.[3] The mercenaries' success led to the spread of their innovations around Europe—to states also in pursuit of security and/or conquest—and to a gradual disintegration of the existing political order. The technology of the pike wasn't just a thing, but a thing embedded in and given meaning by social and political practices. The bundle of practices ("the pike" for short) was transformed and spread by international politics.

The story of the pike symbolizes the objective of this study: to investigate the relationship between technological change and international system change. I make four arguments. First, we have little theoretical understanding of how technology and the international system are related. Second, against those who place technology outside the sphere of social science, I argue that technology is a critical part of the international political system. It is much more than a power resource; it is the medium of interaction for international actors. Third, technology is not just a physical artifact. Technology is part of the structure of international politics; international politics is one of the factors governing technological change. Together they mutually constitute complex sociotechnical systems that are political at their core. Fourth and finally, uncovering this relationship offers insight into the process of international system transformation.

New technologies are not created by exogenous shocks to the international political system. Their transformative properties are not a simple consequence of their material features. Technological systems of communication, transportation, and/or destruction are a permanent, constitutive part of all international systems. Their development and the transformations they engender are conditioned by international politics. Change emerges out of the operations of the international political system itself. I use two case studies—the railroad and the atom bomb—to substantiate these claims. They are both sociotechnical systems that shaped the environment of international politics.

Technology looms across disciplines as a source of social, economic, and/or political change. It is often the master variable that explains everything. In economics, technological change unlocks the mystery of economic growth itself—albeit as a powerful residual variable.[4] In communications theory, in particular that inspired by Harold Innis, communications technology is the central factor shaping the political structure of human societies.[5] Marxism and the various social theories inspired by it explain the structure and change of human society and economy as a consequence of their technological base.[6]

Technology also plays an important role in a range of studies relevant to international politics. Scholars associate most system transformations since the medieval-to-modern transition with technological change. The pike and gun, the sailing ship, and the book have all been linked with the end of feudalism and the emergence of a states system in Western Europe in the seventeenth century. The rise of nationalism and the development of the nation-states system have been explained by the emergence of the newspaper in the late eighteenth and early nineteenth centuries. The geographic expansion of the states system in the nineteenth century is attributed to steamships, railroads, and telegraphs. The development of nuclear weapons in the second half of the twentieth century spawned a large literature on their system-altering effects.[7] The end of the cold war has raised the question of technology and system change again. The spread of digital information technologies has led to speculation on their likely international impact. Some perceive technology to be transforming the nation-state system into something else—a postmodern world order or postinternational politics or a partially globalized world.[8]

In other words, the relationship between technology and international politics is everywhere we look. So it is surprising that there are few attempts in international relations to systematically integrate the two.[9] There is a poor fit between our existing frameworks in international relations and the nature of technology as an object of social and political analysis. Our tools for analyzing political change in international politics, in general, are poorly developed. Static and mechanistic models dominate the discipline of international relations. Factors thought to account for change—technology, the expansion of market economies, developments in military science, or some other force—are placed outside of, exogenous to, international relations models. This approach safeguards rigor and simplicity, but it leaves too much out. The models are mute on the sources of change. Even equilibrium models of change imagine a static system, perturbation by an external shock, adjustment and recovery, and a new equilibrium.[10] These models are apolitical. By placing the sources of change outside the purview of politics (and by giving them autonomous force), static models strongly suggest a deterministic social universe independent of and superordinate to human agents.

I advocate an alternative to these conventional approaches. I conceptualize the sources of international change as endogenous to (inside) the international political system. I argue that international system theory can be adapted to account for change. I do this by redefining the international system to include technology and by theorizing technology as a political phenomenon. The relationship between international politics and technology is fundamental and mutually constitutive. Technology is deeply embedded in international and domestic political practices. What looks to be technologically induced systemic change ("the pike ended feudalism") is instead the evolution of a sociotechnical system that resists separation into the political and the technical. This term, the sociotechnical system, is key to my analysis. Technology is a "special" kind of variable, though. The relationship between international politics and technology does not follow the common logic of actor and role in which mutual constitution means the two are one and the same. The two are not prima facie balanced or equivalent.[11] The evolution of sociotechnical systems follows a path-dependent logic much like institutions. As systems mature, they lock in certain political possibilities and lock others out.[12]

In tracking the development of these sociotechnical systems, I draw on historical sociology and constructivism for theory, and path dependency and process-tracing for method. Historical sociology emphasizes the variability and evolution of political systems and the dual nature of the state constituted by domestic and international forces.[13] When applied to sociotechnical systems, two elements stand out as important: the domestic, international, and transnational institutions that shape their development; and the phases of development and spread of those systems across the international system. Constructivism (of both the international relations and the technology-theory kind) provides the tools to view technology as a political phenomenon. Technical artifacts are constructed by human action and beliefs in the same way social institutions and identities are. In this study, the appropriate methodological question is not *do* technology and system change coincide, but *how* do they? Path-dependency and process-tracing methods for establishing causal relations within cases are well suited to mapping how sociotechnical systems develop.[14] Path-dependent processes are historical sequences in which contingent events establish institutional patterns that become relatively deterministic.[15] I argue that the development and maturation of technological systems follow this logic. Process-tracing allows the investigator to make causal claims when the absence of large numbers of like cases makes covariance methods impractical. Causation is established by temporal succession and contiguity between chains of processes. Technological systems are ill suited for covariance methods. Their development and spread are linked processes. Theories of technology and international politics provide the mechanisms within each case to link stages.

In the next chapter, I develop the argument that new technologies are an important and misunderstood component of system change. Their impact is not a result of simple and unambiguous effects of the material characteristics of the technology. Instead, they interact with the international system as *a part* of that system. I make this argument in three steps. The first step is primarily an analytic exercise familiar to students of international relations theory. I investigate the weaknesses of conventional understandings of international system structure and change and show how, at the level of theory, adding technology to the conception of the system is one solution to their problems. The second step investigates how we should understand technology as a component of political systems. The third step synthesizes the first two and develops a theory of technology, international politics, and international system change.

The first step addresses the nature of the international system and the characterization of international system change. Systemic theorizing in international politics has been important and productive for decades, but the puzzle of conceptualizing and explaining systemic change eludes it. I argue that the dominant theoretical traditions in international politics offer useful conceptions of systemic change, but the causes of change are outside the theories. The realist conception of system change focuses on changes in the distribution of power. Other theoretical traditions broadened the list of sources of significant change, including: changes in the nature of the units in the international system, changes in the level of economic interdependence, changes in unit self-identity, and a shift from subsystem dominance to system dominance.[16] But in all of these conceptions, the sources of change are outside the framework of the theories.

What do I mean by systemic change? The previous examples show that there are a number of available conceptualizations. These conceptualizations are often treated as competitors. Waltz allows for a change in ordering principle, from anarchy to hierarchy, or change in the identity of the important actors and nothing more.[17] Gilpin distinguishes between systems change, systemic change, and interaction change that correspond to change in the nature of the actor, the identities of the great powers, and the rules of the system, respectively.[18] My purposes are better served by combining conceptualizations not choosing among them. Table 1.1 summarizes most of the prevailing understandings in the literature. The kinds of change are arranged in order of descending "importance" or at least relative frequency (changes in the polarity of the system happen frequently; changes to the ordering principle of the system (almost) never happen)—though the order is rough. Neither deductive reasoning nor the historical record are clear on whether, for example, shifts in collective identity are more or less frequent or more or less significant than changes in interaction capacity. Each of these will be discussed in greater detail in the next chapter, but, briefly, the table tells us two things. Each of the changes is to a systemic feature of the system, not to the units (though in some cases the two are the same). There are no good a priori reasons for ruling one or another class of change illegitimate or nonsystemic. Second, the table shows that none of the wide variety of conceptualizations of system change is logically or historically mutually exclusive. A change in the distribution of power can accompany the rise of a new hegemon that may or may not coincide with a shift in the nature of the units. Therefore, my contribution, which focuses on changes to the interaction capacity of the international system, is not intended to supplant other conceptualizations of systemic change, but to deepen and enrich our understanding of the phenomenon.[19]

The second step concerns technology. How should we understand the relationship between technology and politics? The answer to this question is critical to developing an ontology of technology and incorporating it into a conception of the international system. Technology in the political science literature is usually conceptualized as either an independent variable (deterministic) or a dependent variable (instrumental). This dichotomy between determinism (the material characteristics of the technology determine the political results) and instrumentalism (politics governs the development and use

Table 1.1 Typologies of International System Change

Feature of International System	*Nature of Change*	*Dominant Theoretical Tradition*	*Example*
Ordering Principle	Shift from anarchy to hierarchy	Realism, Liberalism	Waltz, Keohane
Nature of Units	Shift in the dominant unit or to/from heteronomy to homonomy	Constructivism	Ruggie, Buzan, Spruyt
Collective Identity	Change in collective identity	Constructivism	Wendt, Adler, and Barnett
Hegemony	Rise of new great power(s)/ hegemonic war	Realism	Gilpin
Interaction Capacity	Technological change	English School, Constructivism	Buzan
Economic Interactions	Increase/decrease in economic interdependence	Liberalism	Keohane and Nye
Distribution of Capabilities	Shift in the identities and/or configuration of the great powers (change in polarity)	Realism	Waltz

of new technologies) is too restrictive. The best studies of the history of technology show how technology and politics are mutually constitutive. Technology is both a social product and an important independent force because it confronts actors as a real resource or impediment. The best way to show this in international relations is by treating technologies as complex sociotechnical systems.[20] Technologies are, in this view, like institutions; they are much more than physical objects. They are bundles of physical artifacts and social practices that together make up a given "technology."

Putting these steps together links the international system and technology. The two cases I investigate involve significant change in what Buzan, Jones, and Little term interaction capacity, which they define as the combination of technological capabilities and shared norms of the international system.[21] Any social system structures interactions among its constituent units. The structuring can be material, in the form of limits on the speed, scope, and character of communication, or normative, where shared understandings define acceptable and unacceptable forms of interactions. I focus on the material half of interaction capacity to bring technology within our theoretical conception of the international political system.

Like the other sources of change in Table 1.1, interaction capacity is a component of the international system, not a characteristic of the system's units; and technology's development is transnational and political. Technological systems are one of the core components of interaction capacity, so technological change can produce change in interaction capacity. Yet these systems are also complex sociopolitical and material entities. Their development and evolution are a transnational sociopolitical process linked by the mechanisms of emulation and diffusion.[22] The evolution of certain complex sociotechnical systems spurs change in interaction capacity; yet the development of these complex sociotechnical systems is simultaneously a complex global political process. Technology and interaction capacity (technology and international politics in essence) are intertwined in a particular set of mutually constituting processes.

The studies of railroad and bomb flesh out these mutually constituting processes. For each case, I need to substantiate four separate claims: first, that each technology is not just a set of material objects, but a complex bundle of artifacts, practices, and institutions. Second, each technology developed in a transnational political setting, not a purely domestic environment. Third, these particular sociotechnical systems became an important part of the international system's interaction capacity. Finally, the change in interaction capacity was systemic change. Each study is divided in two. The first part traces the construction of the sociotechnical system—meeting the first and second claims. The second part discusses the impact of the sociotechnical system on interaction capacity—satisfying the third and fourth.

The first part of the railroad case study begins with its origins in Britain. Britain had advantages over its European competitors in demand for a faster and more efficient inland transportation system, in available capital, in technological resources (the steam engine), and in engineering expertise. So the British were the first to construct a rail network—the combination of ties, tracks, locomotives, rolling stock, lines, firms, schedules, safety regulations, government loan guarantees, and management practices that became the technology of the "railroad."

The industrial revolution was a transnational and competitive process, and the British monopoly did not last long. A home market saturated with railroads and an overabundance of skilled engineers drove large numbers of them out of Britain in the 1820s and 1830s. Many of them were drawn to Germany by new rail projects and recruitment by activist states. The railroad was reimagined and reconstructed in Germany as an instrument of national military power. It was here that the sociotechnical system of the railroad began to mature and rigidify, and it was here that the elements of choice and contingency are clearest. The use of rail was a contentious issue within the Prussian military in the 1850s and 1860s. The bureaucratic methods, educational attainments, and technical expertise necessary to make and manage an effective military rail system did not sit well with the traditionalists. They made no effort to hide their disdain for the "engineers" (who were more likely from a lower social class) on the General Staff who struggled technically to construct a system and politically to win it approval. The success of the system in the Austro-Prussian War consolidated the political position of the modernizers. Only then did the system gain the full support of the Prussian military, and only after the defeat of France in 1870 did it become a model for the rest of the world.[23]

The railroad entered the international system as a military tool. But its speed and carrying capacity did more than vault Germany near the top of the international hierarchy. It also altered the relationship of time and space to security and diplomacy. Railroads vastly expanded the range, speed, and size of armies. Germany was literally made possible by railroads, as their range offered a solution to the two-front problem (France in the west and Austria then Russia in the east) that had hindered unification prior to 1871. Continent-sized states like the United States and Russia were likewise made more feasible by rail transport, as were industrial-era colonial empires that combined political control of large territories with intensive economic exploitation (such as British India). Finally, as a consequence of the state becoming heavily involved with railroad financing, line planning and construction, and civil–military coordination, the railroad also altered state–society relations. States became much more intensively involved in their economies, and military planning extended deeper into peacetime. Thus, the railroad's transportation and security characteristics made it a part of the interaction capacity of the industrial-era international system. The railroad's transformations to force, state composition, and state–society relations constituted systemic change.

The atom bomb case study begins in German universities. It originated as pure theoretical knowledge in the German system in the 1920s and 1930s. The Germans had invented the idea of the research university in the 1870s, and in the early twentieth century dominated the sciences generally and the emerging fields of theoretical and nuclear physics in particular. But these physicists were also part of a transnational knowledge community and the German university system was an object of emulation around the world, particularly in the United States where great resources were available for the sciences.

In the 1910s and 1920s, the exchanges were gradual and diffusion to the United States subtle. A few departments managed to lure Germans to the United States and university positions. But, by the early 1930s, the situation had changed dramatically. The Depression and anti-Semitism drove a large number of German scientists—disproportionately specialists in the fields of quantum and atomic physics—from their positions. Many were drawn to the wealthy and underpopulated American university system where new empire-builders in physics departments across the country openly recruited them.

By the advent of World War II, the center of gravity of nuclear physics had shifted to the United States. The United States drew upon the considerable resources of the diaspora physics community for the Manhattan Project. The war was the crucible in which various stands of pure knowledge were welded to industrial production techniques to produce something thought impossible just a few years before. After the war, the United States used nuclear weapons to protect itself and Europe from Soviet aggression, and to obtain and hold a dominant role in world affairs. Like the railroad, the development of the bomb as sociotechnical system hinged upon choice and contingency. As with the rail case, war was a conjuncture, but there was also a second: the rise of Nazism in Germany. The expulsion of many talented nuclear and theoretical physicists made it highly unlikely that those remaining could direct a successful bomb project.[24] The nuclear physics community had made progress in unlocking the operations of the nucleus, but it is doubtful that a nuclear explosive device would have been constructed in peacetime.[25] The crucible of war was needed to concentrate the resources and talent on the problem.

The bomb had profound consequences for the international system. The United States (and the Soviet Union) constructed elaborate sociotechnical "command and control" systems for the use of the weapon. When wedded to long-distance delivery systems, the bomb shrunk time and space even further and faster than had rail. Its destructive power made nuclear states at the very least highly cautious when confronting each other and many argue it made major war impossible. The bomb also deepened the penetration of the state into peacetime societal relations. Armies at borders could no longer provide security through the management of space, so states turned to the management of technology by forging permanent relations with industry and science. Thus, theoretical physics, instantiated as nuclear weapons, defined the interaction capacity of the atomic era. The bomb's destructive power and speed and its effects on diplomacy and state-society relations meant the changes to interaction capacity were systemic.

The case studies support the book's central argument: technology must be considered as an important, transformative element of the international political system. Their effects on force, security, geography, diplomacy, and state-society relations, and the transnational process that constructed them, make the two examples clearly something more than a unit-level factor—part of the international system. Yet the origins of both technologies were at their core sociopolitical events. Neither the military railroad network nor the fission bomb were 'discovered' by humans; neither were stumbled upon. Instead, each was constructed to perform specific human social, economic, political, or security functions. Each was a product of chance, contingency, and conjuncture. Key choices and events (with foreseen and unforeseen consequences) pushed the development of the technologies one direction and not another with critical consequences for international politics. In my conclusion I sum up and speculate on the likely applicability of this analysis to the information technology revolution.