

**RIDING THE CURVE:
STATE STRATEGY AND TECHNOLOGICAL CHANGE**

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CHAPTER 1:

RIDING THE CURVE: STATE STRATEGY AND TECHNOLOGICAL CHANGE

This project seeks to explain the conditions under which we may expect to see states to seek out and engage in arms control. An important premise of the argument is that the willingness of states to engage in such cooperative behavior will be shaped by their expectations relative to changes in military technology in the foreseeable future. In this chapter, I explore the place of technology in the international relations literature and present a more comprehensive method for understanding the influence of technology on states and their leaders. Technology, and technological change, plays a de facto systemic-level role of creating opportunities and constraints for state actors and thus influences their strategies and behavior. To mitigate the uncertainty inherent in technological change, leaders will develop expectations of the relative impact of military applications of new and emerging technologies and incorporate them into their strategic planning. Statesmen, constrained by scarce resources, cannot simply make worst-case evaluations when determining their investments in military assets. These expectations hold the key to understanding the conditions under which states will seek out or respond favorably to cooperative arms control initiatives.

Technology and International Relations Theory

The notion that all states possess some capacity to hurt one another is a key premise of realism.¹ This capacity to do harm -- military force -- is itself shaped and influenced by the technologies of the day. In a competitive world, we would expect that

¹ John J. Mearsheimer, "The False Promise of International Institutions," *International Security*, 19:3 (Winter 1994/95), pp. 12.

security-maximizing states should seek out and exploit new technologies to gain advantages over a rival or to avoid falling behind. However, such unilateral action could ultimately undermine one's own security by increasing fears in neighbors and set off a spiral dynamic leading to reciprocal deployments with the possibility of crisis or war.² One potential path to peace would be for states to work cooperatively to limit certain existing forces or numbers of assets to mitigate security dilemma dynamic or to agree to forgo future acquisition and deployment of new types of weapons.³ In either case, technology will play a large roll in the ultimate success of such initiatives. Technological change is a powerful force in international relations that exerts an independent influence on state behavior. Understanding how technology and technological change influence states and the system will provide a solid foundation for exploring the conditions under which international arms control may or may not be possible.

From a theoretical point of view, technology has always presented a difficulty for scholars of international relations. In first describing structural realism, Kenneth Waltz placed technology, and technological change, within the domestic realm.⁴ Offensive realists have followed suit, presenting technology as a component or indicator of relative power.⁵ However, it is difficult to conceive of a unit-level factor that has so often influenced systemic outcomes. Waltz himself has since acknowledged the critical influence of nuclear weapons in maintaining systemic stability throughout the later Cold

² On the security dilemma see Robert Jervis, "Cooperation Under the Security Dilemma," *World Politics* 30, no 2 (1978). On the spiral model see Jervis, *Perception and Misperception in World Politics* (Princeton: Princeton University Press, 1976).

³ Charles Glaser, "Realists as Optimists, Cooperation as Self-Help," *International Security* 19:3 (Winter 1994/1995)

⁴ Kenneth Waltz, *Theory of International Politics* (McGraw-Hill: 1979), 180-181.

⁵ John J. Mearsheimer, *The Tragedy of Great Power Politics* (W.W. Norton & Co.: 200), 75.

War⁶, but looking throughout military history it is not difficult to find numerous examples of states who first exploit new technologies on the battlefield achieving decisive results.

The successes of Helmut von Moltke's Prussian Army against Austria in 1866 and then against France in 1871 were both examples of a numerically inferior force utilizing new technologies, namely railroads and the breech-firing "needle gun" to overcome numerically superior forces.⁷ In strict relative power terms, we would have expected Austria and France to defeat Prussia, but instead at Konnigratz and later at Sedan, Prussian forces annihilated their counterparts by employing the greater mobility provided by railroad against both Imperial Armies. The Prussian military also utilized improved firepower of the Dreyse needle gun against the Austrians and modernized Krupp field artillery against the French with impressive results. Similarly, few observers at the time expected Japan to decisively defeat the Russia in 1904, and while the war on land dragged on the shocking annihilation of the Czar's fleet off the island of Tsushima was indeed decisive.⁸ Yet Japan's investment in top-of-the line warships from Great Britain and its concerted efforts to develop a formidable navy in the decades preceding

⁶ Waltz, *Theory of International Politics*, and his "The Emerging Structure of International Politics," *International Security* 18:2 (Fall 1993) pp. 44-47. See also Robert Jervis, *The Meaning of the Nuclear Revolution Statecraft and the Prospect of Armageddon* (Ithaca: Cornell University Press, 1989).

⁷ On the Prussian successes, see for example: Arden Bucholz, *Moltke and the German Wars, 1864-1871*, (New York, New York: Palgrave, 2001); Geoffrey Wawro, *The Austro-Prussian War: Austria's War with Prussia and Italy, 1866*, (Cambridge University Press, 1997); Gordon Craig, *The Battle of Koniggratz: Prussia's Victory over Austria, 1866*, (Philadelphia: University of Pennsylvania Press, 2003); Michael Howard, *The Franco-Prussian War: The German Invasion of France 1870-71*, (London: Routledge, 2001); Hajo Holborn, "The Prusso-German School: Moltke and the Rise of the General Staff," and Gunther Rothenberg, "Moltke, Schlieffen, and the Doctrine of Strategic Envelopment," in Peter Paret (Ed.) *The Makers of Modern Strategy from Machiavelli to the Nuclear Age* (Princeton: Princeton University Press, 1986);

⁸ Denis and Peggy Warner, *The Tide at Sunrise, a History of the Russo-Japanese War* (London: Frank Cass, 1975); J.N. Westwood, *Russia Against Japan, 1904-5: A New Look at the Russo-Japanese War* (State University of New York Press, 1986); Walder, David, *The short, victorious war: The Russo-Japanese Conflict* (London: Harper Collins, 1974).

the war set the stage for a rout that shook the Russian government and proved a devastating national embarrassment. In both of these cases, two “middle” powers seeking to improve their security by engaging in strategies of innovation and adaptation were able to defeat acknowledged great powers and achieve great power status.

The combined arms approach of Nazi Germany’s Blitzkrieg annihilated not only a weak Polish military, but a numerically superior French force, and almost succeeded in knocking the massive Red Army out of the war during Operation Barbarossa.⁹ The subsequent miscalculations of Hitler and his general staff aside, Blitzkrieg illustrates the potential benefits of successful military innovation and the sobering costs of failing to keep up or allowing one’s military to atrophy in the face of an innovative rival.

In a less dramatic but equally important way, major improvements in logistics and supply derived from the “second” industrial revolution, played a decisive role in the combined British and French successes against seasoned and experienced Russian forces in the Crimean War.¹⁰ Projecting force over a long distance is a particularly difficult challenge, and we would typically expect a defending force, fighting closer to base areas to have a “built-in” advantage relative to the tasks of re-supply and reinforcement. But it

⁹ Several authors have written detailed accounts of the military debacle and the political interactions preceding it. See for example: Alan Clark. *Barbarossa, The Russian-German Conflict, 1941-1945*, (New York: William Morrow & Co., 1965); John Erickson and David Dilks (eds.). *Barbarossa: The Axis and the Allies*, (Edinburgh: Edinburgh University Press, 1994); John Erickson. *The Road to Stalingrad: Stalin’s War with Germany Vol.1*, (New York: Harper and Row, 1975). David M. Glantz has written widely on Barbarossa and the Red Army more broadly. His key works include: *Barbarossa: Hitler’s Invasion of Russia, 1941*, (Charleston: Tempus Publishing, Inc., 2001); *When Titans Clashed: How the Red Army Stopped Hitler*, (Lawrence: University Press of Kansas, 1995) (edited with Jonathan House); and *The Initial Period of War on the Eastern Front, 22 June – August 1941*, (London: Frank Cass, 1993). Richard Overy’s *Russia’s War*, (London: Allen Lane, 1998), also provides an excellent account of the war and its early stages.

¹⁰ On the Crimean War see for example: Ian Fletcher and Natalia Ishchenko, *The Crimean War: A Clash of Empires*, (Spellmount Publishers, 2004); Trevor Royle, *Crimea: The Great Crimean War*, (New York: Palgrave Macmillan, 2004); and Winfried Baumgart, *The Crimean War, 1853-1856*, (London: Arnold Publishers, 1999). On the importance of the allied logistical advantage, see: William H. McNeill, *The Pursuit of Power* (Chicago: University of Chicago Press, 1982) pp. 230-231.

was the utilization of new technological applications provided by the industrial revolution that allowed the allies to defeat the Russian forces and capture the key port of Sevastopol, effectively ending the conflict.

While some would leave the stories of Prussia, Japan, Nazi Germany, and the victory of the allies over Russia in the Crimea as simply reflections of their increased relative power vis-à-vis declining competitors, such an analysis would be an overstatement, and over-determined. In these cases new technologies were utilized by innovative militaries to achieve stunning victories against what could only be classed as equal or superior rivals. It is true that “great powers not only imitate each other’s successful practices, they also prize innovation.”¹¹ This is precisely why subsuming technological change within measures of relative power is not only analytically imprecise, but risks missing the real story behind a state’s military and political development vis-à-vis other states. It also overlooks a potentially important influence on state behavior -- the impact of technological change.¹²

The Offense-Defense Balance

The only explicit and systematic attempt to incorporate technology into international relations theory is the offense-defense balance. Defensive realists focus on the offense-defense balance as an important variable for understanding the likelihood of conflict or peace, alliance formation, and or cooperation between states or within a given

¹¹ Mearsheimer, *The Tragedy of Great Power Politics*, p. 166.

¹² In comparative politics there has been more of a conscientious discussion of the impact of technological change and the development of the nation state in Western Europe. See for example: Michael Mann, *The sources of social power 1: A history of power from the beginning to AD 1760*, (---)Charles Tilly, *Coercion, Capital, and European States, AD 990-1992*, (Cambridge, Massachusetts: Blackwell, 1992) Geoffrey Parker, *The Military Revolution Military innovation and the rise of the West 1500-1800*, Second Edition, (Cambridge: Cambridge University Press: 1996);

system.¹³ Stripping away factors from more expansive definitions of the offense defense balance, we are left with a core variable that incorporates geography and technology.¹⁴ This relatively straightforward measure allows us to classify given systems as offense or defense dominant (or perhaps neutral) at a given time, and from these measures we can attempt to understand the political pressures placed upon states at a given time. Offense dominance forces states to be on high alert because a first strike could be decisive. Hard-line diplomacy and pressures toward preemption (that is attacking first for fear of an imminent strike by a rival) will make cooperation of any sort exceedingly difficult.¹⁵ Conversely, when a system is defense dominant, states have less to fear from a first strike. They can afford to bargain with rivals because an attack is less likely to prove decisive. An important caveat, and one often made by critics of the theory is the ability of leaders to actually distinguish between offense- and defense-dominant systems.¹⁶ For example, the case of World War One is often used as a critique of the offense-defense balance because it is generally thought that leaders expected a quick and decisive war and

¹³ For definitions and discussion of the offense-defense balance see: Robert Jervis, "Cooperation under the Security Dilemma"; Charles L. Glaser and Chaim Kaufmann, "What is the Offense-Defense Balance and Can We Measure It?" *International Security* 22:4 (Spring 1998); Stephen Van Evera, "Offense, Defense and the Causes of War," *International Security*, 22:4 (Spring, 1998); and Sean Lynn-Jones, "Offense-Defense Theory and Its Critics," *Security Studies* 4:4 (Summer 1995). For an interesting debate on the subject see "Correspondence: Taking Offense at Offense-Defense Theory," *International Security* 23:3 (Winter 1998/99).

¹⁴ By shedding such factors as nationalism, cumulativeness of resources, and military doctrine, we are also able to maintain the offense-defense balance as a structural variable. Kier Lieber makes this point in *War and the Engineers*, (Ithaca: Cornell University Press, 2005), pp.33.

¹⁵ For a thorough discussion of this logic, see "Jumping the Gun: First-Move Advantage and Crisis Instability," the third Chapter of Steven Van Evera's *Causes of War, Power and the Roots of Conflict*, (Ithaca: Cornell University Press, 1999), pp. 35-72.

¹⁶ An important criticism of the offense-defense balance has been the difficulty of distinguishing between offensive and defensive weapons. Jervis discussed the problem in *Cooperation Under the Security Dilemma*, 199-206. John Mearsheimer presents a strong argument against the ability of states to distinguish between offensive or defensive weapons in *Conventional Deterrence* (Ithaca: Cornell University Press, 1983), pp. 25-28. Lieber echoes these arguments in *War and the Engineers*, pp.35-45.

the ensuing conflict proved to be quite the opposite.¹⁷ What this debate seems to overlook, however, is that the offense-defense balance, at any given point in time, is merely a constraining factor. It will act as a consideration for state leader to account for when developing strategies, but it can also be overcome and (in the longer term) overturned by the actions of states and their leaders. What is often missed in the discussions of offensive illusions and defensive realities in the context of the outbreak of World War I, the Schlieffen Plan almost succeeded, and was seemingly executed with a knowledge of the difficulties that a more defensive security environment would present. Had it succeeded, we would not necessarily type the environment as offense-dominant, but merely that German action was able to overcome the constraints of the existing system.¹⁸

The advent of nuclear weapons has created a third case for the offense-defense balance, one that would be correctly-termed “deterrent dominance.”¹⁹ While the achievement of universally acknowledged assured destruction capabilities by both superpowers in the second decade of the Cold War effectively shifted the superpower rivalry to an environment of defense dominance, it is important to note the key difference. Both states realized that the destruction created by guaranteed second strikes made offensive operations self-defeating, given the costs that each would subsequently assume. But this is the result of an admission that defense was virtually impossible, and that offense (the ability to hurt the other) had achieved such an overwhelming advantage

¹⁷ See Jack Snyder, *Ideology of the Offensive: Military Decision Making and the Disasters of 1914* (Ithaca: Cornell University Press, 1984)

¹⁸ For example Spencer C. Tucker, *The Great War 1914-1918* (London: University College press, 1999), pp. 22. Marc Trachtenberg also discusses this in “Strategy and War,”

¹⁹ Karen Ruth Adams discusses this in her piece, “Attack and Conquer? International Anarchy and the Offense-Defense-Deterrence Balance,” *International Security* 28:3 (Winter 2003/2004), pp. 45-83. Glenn

that any conflict became irrational.²⁰ Even this delicate balance of terror did not, however, allow the two states to avoid conflicts and crises that held the possibility of mutual annihilation.²¹ Nor did this fact of life necessarily end the superpower rivalry and lead to cooperation as defensive realist might expect.²²

Given that geography will remain a constant between given sets of states over time, technology becomes the operative factor in the offense-defense balance. Whether a given combination of weapons systems available favors offensive or defensive operations may be important for understanding relationships between states at a given time, but the offense-defense balance has rightly been criticized for being overly static. If a system was indeed objectively defense-dominant at a given time, it is still possible, given the dynamic nature of technology, for states to adapt to effectively change or overthrow the systemic bias. This is not to say that the offense-defense balance is not a useful concept, only that it should be seen as a systemic snapshot, and a temporally

Snyder made the argument in his book *Deterrence and Defense, Toward a Theory of National Security*, Princeton: Princeton University Press, 1961).

²⁰ Other discussions of offense-defense balance reflect this fact and thus type the assured destruction as “defense-dominant.” See for example Jervis, “Cooperation Under the Security Dilemma,” 198; Lynn-Jones, “Offense-Defense Theory,” p. 676; and Van Evera, *Causes of War*, p. 246.

²¹ The early crises of the Cold War brought the world perilously close to annihilation and the U.S. was willing to threaten the use of nuclear weapons. See Richard K. Betts, “A Nuclear Golden Age? The Balance Before Parity,” *International Security* 11:3 (Winter 1986/87) pp. 3-32. See Dale Copeland’s discussion of the Berlin and Cuban crises in *The Origins of Major War* (Ithaca: Cornell University Press, 2000), Chapter 7. On the Cuban Missile Crisis see for example: David A. Welch, James G. Blight and Bruce J. Allyn, “Essence of Revision: Moscow, Havana, and the Cuban Missile Crisis,” *International Security* 14:3 (Winter 1989/90); Aleksandr Fursenko and Timothy Naftali, “One Hell of a Gamble”: *Khrushchev, Castro, and Kennedy, 1958-1964* (New York: W. W. Norton, 1997); and Robert Kennedy, *Thirteen Days* (New York: Norton, 1968). On the precipitous nature of the early Cold War see for example: John Lewis Gaddis, *We Now Know: Rethinking Cold War History* (Oxford: Oxford University Press); Melvyn P. Leffler, *A Preponderance of Power: National Security, the Truman Administration and the Cold War* (Stanford: Stanford University Press, 1992); and Marc Trachtenberg, *The Constructed Peace* (Princeton: Princeton University Press, 1999).

²² Mutual acknowledgement of “assured destruction” seems to have been crucial to what became the stability of the later Cold War. The early writers on deterrence first saw the importance of this reality and focused on the need for stability and avoiding situations that could make launching a war appear attractive or fathomable. See for example: Snyder, *Deterrence and Defense*; Bernard Brodie, *Strategy in the Missile Age* (Princeton: Princeton University Press, 1965); and Brodie, *War and Politics* (New York: MacMillan,

bounded systemic constraint, whose longevity will often be determined by the nature of the technologies involved.

Consider a brief example. Most scholars consider the trench warfare of World War I as a clear case of defense-dominance. The combination of fortified installations, barbed wire, machine guns, and artillery made offensive operations prohibitively costly.²³ In two distinct ways, Germany was able to overcome this situation in two timeframes. First, the German military, through tactical innovation, was able to develop infiltration units to puncture enemy lines toward the end of the war.²⁴ Twenty years later, utilizing new technologies, the military leadership of the Third Reich had developed, in Blitzkrieg, a combined arms approach to operational warfare that overturned any defensive advantages of the World War I era.²⁵ In both cases, defense dominance was overcome by the premeditated, purposeful attempts of a given state. In the second case, we see how military leaders, with knowledge of the challenges of the last war firmly in mind, could transform the future battlefield by employing new technologies within innovative doctrine, lending credence to arguments that technology is an endogenous factor shaped by states. Actors can manipulate technology, particularly over some finite period of time. We could also envision a situation where systemic defense dominance was simply

1973); Thomas Schelling, *Arms and Influence* (New Haven: Yale University Press, 1966); and Schelling and Morton H. Halperin, *Strategy and Arms Control* (Washington: The Twentieth Century Fund, 1985).

²³ See Van Evera, "The Cult of the Offensive and the Origins of the First World War," and *Causes of War*; Scott D. Sagan, "1914 Revisited: Allies, Offense, and Instability," *International Security* 11:2 (Autumn 1986) pp. 151-175.

²⁴ Jonathan Shimshoni, "Technology, Military Advantage, and World War I, A Case for Military Entrepreneurship," *International Security* 15:3 (Winter 1990/91), pp. 187-215.

²⁵ On the development of Blitzkrieg see for example: James S. Corum, *The Roots of Blitzkrieg, Hans von Seeckt and German Military Reform* (Lawrence: University of Kansas Press, 1992); Robert Citino, *Quest for Decisive Victory: From Stalemate to Blitzkrieg in Europe, 1899-1940* (Lawrence: University of Kansas Press, 2002) and Citino, *The Evolution of Blitzkrieg Tactics: Germany Defends Itself Against Poland, 1918-1933* (Westport: Greenwood Press, 1987); Mary R. Habeck, *Storm of Steel, The Development of Armor Doctrine in Germany and the Soviet Union, 1919-1939* (Ithaca: Cornell University Press, 2003); Heinz Guderian, *Panzer Leader* (Cambridge: De Capo Press, 1996) and Guderian *Achtung Panzer!*

overwhelmed because an invading force employed assets in such quantities that sheer numbers offset the advantage of the (numerically inferior) defenders.²⁶ In such a case, the offense-defense balance is vitiated by relative power and military technology doesn't play much of a role. The fact that the Schlieffen Plan almost succeeded (and would likely have succeeded either two decades earlier or two decades later given the military technologies of the times) reflects the fact that the offense-defense balance is a constraint, and one that can be overcome by concerted effort and effective planning.²⁷

In these three cases, a defensive advantage can be overcome in three ways: tactical innovation "on the fly", the development of new strategy and operational doctrine utilizing new technologies over some period of time, or the utilization of overwhelming power. In the second case, technological change will clearly have the greatest impact, by effectively overturning the system, not merely overcoming its constraints. It is not to say that the deployment of new technologies will always deliver such rewards. The development of doctrine and tactics that successfully exploit new technologies and place them within a coherent overall framework will often determine ultimate effectiveness.²⁸ Often, this success will only become apparent during a war. It is also important to note that the pace of technological change has not always moved as quickly as we have seen in the early part of the twentieth century.²⁹ Throughout history, technology has remained relatively stable for long periods of time, leaving the nature of warfare relatively unchanged for decades, if not centuries. With the key development of state bureaucracies

²⁶ Mearsheimer, *Conventional Deterrence*.

²⁷ See Trachtenberg, *History and Strategy*

²⁸ See Barry Posen, *The Sources of Military Doctrine: France, Britain, and Germany between the World Wars* (Ithaca: Cornell University Press, 1983).

²⁹ Jack S. Levy, "The Offensive/Defensive Balance of Military Technology: A Theoretical and Historical Analysis," *International Studies Quarterly* 28:2 (June 1984) pp. 219-238; Barry Buzan and Eric Herring, *The Arms Dynamic in World Politics* (London: Lynne Rienner, 1998), Chapter 2.

focused on the development and procurement of new weapons systems and the underlying development of technological capabilities made possible by the industrial revolution, advances in military technology became a regularity.

By the middle of the nineteenth century, a fundamental transformation in military technology was under way. The industrial revolution, with its ever expanding use of energy and machinery in the process of production, had by this time developed such momentum that major changes in technology began to occur frequently. From around the middle of the nineteenth century, a new norm of frequent change asserted itself. That norm still prevails. It shows little sign of weakening...³⁰

Over time the pace and scope of technological change has intensified with dramatic implications for states. The comfort of any defensive advantage would seem fleeting. In fact, the nature of technological change would seem to imply that statesmen can never feel too comfortable with any advantage, precisely because potential rivals may overcome it through concerted efforts or because of some seemingly unrelated breakthrough that happens to provide new capabilities that vitiate the initial advantage. In an uncertain world, technological change offers its own set of problems for statesmen to manage. The offense-defense balance only partially captures these difficulties.

The Implications of Technological Change: Technological Uncertainty

As we have seen, the acquisition and deployment of new technologies can often have dramatic political ramifications without the occurrence of war, however. Many of the arms races of the last century were in fact spurred by the fielding of new weapons systems that threatened to alter existing strategic balances by one state, leading to a similar acquisition by potential competitor, or the acquisition of systems to offset or counter the initial deployment. Both the French and German attempts to usurp British battleship dominance were attempts to acquire and deploy newer, more powerful ships

³⁰ Buzan and Herring, p.12.

with capabilities that surpassed existing British vessels.³¹ In both cases, however, Britain relied upon its underlying industrial shipbuilding capacity to meet and overcome the challenge. The mere possession of a new technology has pressured states to use it before another obtains it. This dynamic was never more apparent than in the serious discussion among U.S. policymakers to preventively attack the Soviet Union before it achieved a nuclear capability.³² Realizing the terrible power of atomic weapons and fearing the loss of the nuclear monopoly over a dubious rival, these advisors saw a decisive first strike as the only way to forestall the inevitable acquisition of atomic weapons by the Soviets. Though Truman and his top advisors ultimately ruled against such an option, it was considered and advocated by important (predominantly military) circles of the political-military establishment. This is an extreme example, but clearly technological change can have a major impact on the political relations between states. Yet if we acknowledge that technological change, particularly the military implications of technological change, has dramatically influenced the nature of international politics over time, it seems problematic to relegate this critical variable to the unit-level. This is not to say that, “it’s all about technology,” and certainly not to be “technologically-determinist,” but simply to state that technological change affects systemic outcomes and this has not been adequately reconciled theoretically.

³¹ Samuel P. Huntington, “Arms Races: Prerequisites and Result,” *Public Policy*, 1958, pp. 41-83.

³² See for example: Marc Trachtenberg, “A ‘Wasting Asset’: American Strategy and the Shifting Nuclear Balance, 1949-1954,” *International Security* 13:3 (Winter 1988/89) pp. 5-49; David Alan Rosenberg “The Origins of Overkill: Nuclear Weapons and American Strategy, 1945-1960,” *International Security* 7:4 (Spring 1983) pp. 3-71; and Rosenberg, “A Smoking Radiating Ruin at the End of Two Hours, Documents on American Plans for Nuclear War with the Soviet Union, 1954-1955,” *International Security* 6:3 (Winter 1981/82) pp. 3-38;

Kier Lieber has rightly asserted the primacy of politics over technology in his presentation of the concept of “technological opportunism.”³³ Ultimately, technology serves state interests and the development of new capabilities to better achieve state objectives is precisely the type of state activity that one would expect in a competitive, self-help environment. At the same time, Lieber fails to adequately acknowledge the importance of technological change as an independent factor at work in the international system. He rightly points out that states do not necessarily follow from the constraints and opportunities seemingly offered by the offense defense balance. But that is precisely what the previous discussion was attempting to explain. Whereas the offense-defense balance is ultimately predicated on a variable that is itself dynamic, states understand that its real effects are fleeting and temporally bounded. It can be overcome in the short-term through the use of overwhelming force or through tactical innovation. More importantly, it can be overturned through proactive state investment and deployment of new capabilities. Particularly since the industrialization of the mid-1800s when states moved from being passive consumers of military technology to active consumers and producers of new military applications we have seen a more regular and purposeful search for new capabilities by military and political leaders.³⁴ This important dynamic has changed the way technology affected states and, in turn, transformed the impact of technology throughout the system.

³³ Lieber, *War and the Engineers*, pp. 4-7.

³⁴ This important threshold has been discussed at length by Buzan and Herring, *The Arms Dynamic in World Politics*, pp. 11-28. William H. McNeill discusses the historical and social trends in European development that culminated in the “bureaucratization of violence” and the “industrialization of war” in *The Pursuit of Power, Technology, Armed Force and Society*, Chapters 5-8. The key point is that states developed a capacity to directly and proactively influence their ability to acquire and deploy new applications of existing and emerging technologies, rather than being passive consumers.

Glenn Snyder has attempted to address the problem of locating technology and technological change by conceptualizing technology as a “structural modifier.”³⁵ His conceptualization is worth quoting at length:

Military technology may also be treated as a structural modifier. Technological change affects all great powers, at least potentially; thus it is inherently a systemic variable, not a unit attribute. It is not fully structural since it does not markedly affect either anarchy or the distribution of resources, yet it is akin to structure through its effects on the nature of military resources. Technological change should be treated as a modifier of theoretical conclusions reached from structural analysis alone. In that role it may have substantial effects in increasing the determinacy of structural analysis.³⁶

This conceptualization begins to uncover the difficulty of describing and explaining the precise role of technology in (particularly modern) world politics, but Snyder does not develop the concept further. His discussion reflects the potential importance of technology, but the notion of a structural modifier seems to limit the explanatory impact of technological change and minimizes the influence of technological change on states, their leaders and ultimately, the system.

As we have discussed above, to some degree, technology is structural, particularly when we consider that states must constantly be aware of the advances and breakthroughs of other states. The pressure created by technological change in states is real and the responses to these pressures will shape state strategies and guide state behavior.

Similarly, states will have access to the new technologies through interactions with other states, though it is true that this access may be uneven as the literature on technological diffusion shows.³⁷ The notion of the security dilemma is driven by the dynamic of arms acquisition and deployment, and over time we have seen that it is often the type of new

³⁵ Glenn H. Snyder, “Process Variables in Neorealist Theory,” *Security Studies* 5:3 (Spring 1996) pp. 167-192.

³⁶ *Ibid.*, p. 170.

³⁷ See for example: Emily O. Goldman and Leslie C. Eliason (eds.), *The Diffusion of Military Technology and Ideas* (Stanford: Stanford University Press, 2003); and Theo Farrell and Terry Terriff (eds.), *The Sources of Military Change, Culture, Politics, Technology* (Boulder: Lynne Reimer, 2002).

weapons systems deployed that drive fears in other states rather than increasing gross numbers of existing assets. At the same time, there is clearly an element of state choice involved when discussing the acquisition and deployment of new technologies, and a question of preexisting state capacity when considering a state's ability to keep up with rivals or maintain a technological edge over them. Thus from a theoretical viewpoint, technology is indeed fuzzy. It cannot be easily placed at either the systemic or unit levels – it is at work on both levels. What we can focus on is the systemic-level influence, the political concerns created by technological change that is at work on all states in a given system. This will be discussed more below.

Thus, with respect to the international relations literature, questions of technology and the impact of innovation and technological change have been somewhat overlooked. Instead, the investigation of technology has seemingly been left to the realm of strategic studies or military affairs.³⁸ But to limit or circumscribe the analysis of technology to these sub-fields also seems unsatisfying. While the works of these fields often provide exciting analyses of specific cases, too often larger patterns are left unexamined and broader questions left unanswered. Few generalizable hypotheses that may work across time or space are generated from this body of work. In fact, many scholars are uncomfortable with the notion that meaningful patterns or transportable hypotheses can be distilled from specific historical cases.³⁹ What seems clear is that the impact of technological change has grave consequences for the security of states and is thus essential to understanding international relations. This study thus seeks to fill an

³⁸ Excellent studies on military innovation include: Williamson Murray and Allen R. Millet, *Military Innovation in the Interwar Period* (Cambridge: Cambridge University Press, 1996); MacGregor Knox and Williamson Murray, *The Dynamics of Military Revolution 1300-2050* (Cambridge: Cambridge University

important gap in the international relations literature by exploring the larger impact of technology and technological change on state behavior. First it is important to define military technology and then address the difficulty of conceptualizing technology in theoretical terms.

Understanding Technology and its Influences on States and the System

Technology is clearly an important force in international relations, but it is difficult to neatly place into any preexisting analytical frameworks. The offense-defense balance is at best static “snap-shot” of a given system at a given time. Technological change may be uneven and difficult to predict, and even the realization that innovations may be somewhat of a regular occurrence does not dispel the high degree of uncertainty associated with technological change. Given the importance of maintaining a military edge to the overall goal of safeguarding the security of the state, statesmen must focus on the implications of technological change for their existing and future military capabilities. This is precisely why technological uncertainty, the uncertainty relating to the types of assets and capabilities that may be available at a given point in the future with respect to one’s own and also a potential adversary’s arsenals, is so troubling. The remainder of this chapter attempts to create a useful definition of technology and examines its influence at both the systemic and state levels.

Defining Military Technology

Certainly, part of the difficulty in attempting to comprehensively address technology is conceptualizing it as a variable. How do we define technology? It may be tempting to limit our understanding to the material “hardware” outputs of technological

Press, 2001); Stephen Peter Rosen, *Winning the Next War: Innovation and the Modern Military* (Ithaca: Cornell University Press, 1991).

breakthroughs. Iron swords, muskets, repeating rifles, tanks, bombers and intercontinental ballistic missiles would represent only a few of technological innovations that have dramatically affected battlefield outcomes throughout history. For the purposes of this study, a more complete view would move beyond just hardware. "...[I]t is helpful to see technology as more than hardware, and the same can be said of military technology, which is hardware intended for organized political violence combine with a wide range of skills needed to create, adapt, reproduce, operate, and maintain it."⁴⁰ What this begins to capture is that technology is not merely material tools or objects but also the software or knowledge to effectively utilize those material objects.

Thus an important role emerges for the development of relevant military doctrine, tactics, and training to develop human capacities to effectively employ new hardware on the battlefield. It also reflects the existence of the societal factors behind the development of specific technologies that contribute to its invention and production. The obvious analytical problem then becomes how far to take this component of human capacity? "Behind military hardware there is hardware in general, and behind that again there is technology as a certain kind of knowhow, as a way of looking at the world and coping with its problems."⁴¹ Such factors as education, intelligence, experience among others could all contribute to the effective employment of new technological applications but these should be considered analytically distinct from software. These factors are better considered underlying attributes of the state in question (or specifically its military), and are very much an empirical question at any given point. In a similar way,

³⁹ Murray and Millett argue so much in *Military Innovation in the Interwar Period*, p. 4.

⁴⁰ Buzan and Herring, *The Arms Dynamic in World Politics*, p. 4.

⁴¹ Martin Van Creveld, *Technology and War From 2000 B.C. to the Present*, (New York: The Free Press, 1991) p. 1.

the developmental level and the underlying technological and industrial base of a given state is an important factor in understanding a state's ability to create and produce new innovations in military technology. Certainly, levels of investment, whether public or private, in research and development will have an impact on how well a state does in terms of developing new technologies, but this too is something that should be seen as analytically distinct from military technology. There are the "inputs" necessary to adequately develop new capabilities. It is thus useful to distinguish the place of technology in the following way.⁴²

[INSERT FIGURE 1 HERE]

The figure illustrates the way in which state or societal factors on what could be roughly described as the "inputs" on the capital and labor sides of the equation support the development of technology and its "outputs," hardware and software. These factors are closely related but are analytically distinct. This formulation begins to give us an understanding of how indigenous technological development in one state would take place, for lack of a better term, organically. Yet we also know that states are not discreet entities sealed off from the world around them. Technology "moves," both in terms of a

⁴² This formulation again reflects the threshold condition that states have, to some degree, achieved the necessary levels of bureaucratization to influence control over their indigenous military-industrial capacities and or can access external sources of military industrial capacity through trade. This is not to put forward a "command economy" model of arms development and acquisition. Rather it reflects an underlying state capacity to be an active player in the development, acquisition and deployment of new military applications of existing or emerging technologies. Most of the "great powers" achieved this potential around the turn of the twentieth century after the industrialization of the mid-1800s. See McNeill, *The Pursuit of Power*, Chaps 7 & 8; Van Creveld, *Technology and War*, Chaps 11 & 15; and Buzan and Herring, *The Arms Dynamic in World Politics*, Chaps 1 & 2. For an example of different paths states can take to achieve innovation, see for example: Matthew Evangelista, *Innovation and the Arms Race: How the United States and the Soviet Union Develop New Military Technologies*, (Ithaca: Cornell University Press,

general quantitative advancement of technological applications that offer new or improved capabilities, and across and among states in a given system.

*The Movement of Technology: Qualitative Advance and Spread*⁴³

We can understand the movement of technology in what can be roughly conceptualized as vertical and horizontal dimensions. Qualitative advance can be understood as the underlying progression of technology. It is in no way limited to the military sphere. In fact, the qualitative advance of technology is often driven by the energies of the civilian sector, with military applications of innovations created in the civilian sector following sometime after the initial discovery or breakthrough.

Some see technological advance as an expression of human intelligence; some see it as a historical manifestation of Western civilization; some see it as a product of the competitive, materialist, and profit-oriented ethic of capitalism; and some see it as a result of the revolution in thinking unleashed by the discovery of the scientific method. Whatever the answer, the point is that the process of technological advance now has a momentum that is deeply rooted in human society. Just as this process cannot be implanted in less industrialized societies without transforming their indigenous cultures, so it cannot be stopped where it already exists without destroying much of the social structure that generated it and that now depends on its continuance.... At the same time as technology appears to transcend the state, it also bolsters the state by providing an immense increase in the size and variety of resources available to support the purposes of government. Highly organized societies are able to extract much more productive energy from their populations than had hitherto been possible. This organizational factor contributed as much to the power of the state possessing it as did the hardware of the industrial age.⁴⁴

For leading states, the challenge is therefore to maintain their position on the leading edge of the qualitative advance of technology. They do this by investing in research and development and fostering the (often civilian oriented) industrial and technical capacities necessary to exploit the beneficial applications of new or emerging technologies.

1988). What is important to note is that both superpowers clearly were active in the development of new technologies but in qualitatively different ways.

⁴³ This is an important notion developed by Buzan and Herring in *The Arms Dynamic*. It reflects the idea that technology advances, more or less exogenously, providing new opportunities for leading states who are best able to exploit new opportunities. At the same time, technology spreads, often in uneven ways from leaders to secondary states and so on, depending on those states capacities. See particularly Chapter 2 & 3.

⁴⁴ Buzan and Herring, pp. 20-21.

Technology also moves “horizontally” throughout the system from leading states to developing ones. Innovations spread throughout systems of states, albeit in uneven ways. “Advanced military technology has spread throughout the international system in three ways: by the physical and political expansion of those states possessing it; by the transfer of weapons from those capable of manufacturing capability them to those not; and by the spread of manufacturing capability to ever more centers of control.”⁴⁵ Given the nature of the technology in question and the underlying capabilities of states to exploit and adapt to what start off as international exemplars or models, states may be able to build upon the work of others or at least imitate successful applications. States can build up their own organic or indigenous industrial-technical capacities to develop what ultimately will be their own technological innovations and military applications.

Moreover, because of the opportunity to purchase technology from other states or other international actors, the arms trade, it may be possible to improve one’s military technologies relatively quickly without making improvements to the underlying industrial-technical base of the state in question. The purchase of “off-the-shelf” (OTS) applications of cutting edge technologies may allow states to rapidly catch up to leaders in terms of the forces fielded at a given time. In recent history, we have also seen how breakthroughs in civilian technology have been harnessed for military purposes particularly in the realm of communications and command and control. Dual-use technology, that which can be utilized for civilian and military purposes is often a contentious issue between trading partners. Acquisition of this technology is particularly interesting because it may allow the recipient state to move beyond initial military improvements to more broadly improve its underlying base and facilitate its own

⁴⁵ Buzan and Herring, pp. 33.

indigenous development from that time on. This only reinforces the notion that technological change can come from a wide array of sources, many quite outside of the purview or direct control of governments. As previously mentioned, there are often no clear lines between military and civilian technology.⁴⁶ This point is worth noting particularly when we discuss the inherent uncertainty associated with technological change. It is often difficult to know where the next critical application may come from, making surveillance and assessment of other states' programs particularly dubious.

Given this discussion of qualitative advance and spread, we can see is that innovators may create for themselves windows of opportunity to employ new military applications before those applications are acquired and deployed by others, but it is unlikely that such windows will remain open long. The competitive nature of the anarchic system will drive states to seek out new technological applications that may improve their own security. In the same vein, states will also carefully examine the activities of other states and remain vigilant with regard to the research, acquisition, and deployment of new military applications.

The relationship between spread and qualitative advance is more complicated than the simple one of leaders and followers: each process actively promotes the other. The process of spread stimulates that of advance, because only by staying ahead in quality can some states maintain their power position and/or their military superiority.... The leading edge of technological advance sets the standard for the international system and its continuous forward movement exerts pressures on the whole process of spread. As the leading edge creates ever higher standards of military capability, followers either have to upgrade the quality of their weapons or else decline in capability relative to those who do.⁴⁷

Understanding this dynamic movement of technology, it is now possible to reexamine theoretical discussions of the international system and the state to better understand and explain the role technology plays in world politics. Moreover, it is possible to examine

⁴⁶ Buzan and Herring, pp. 20-23

⁴⁷ Buzan and Herring, p. 30.

states strategies in the context of technological change, and to discern recurring patterns of state behavior that are shaped and influenced by concerns and expectations of technological change.

Technology and the System

In international relations theory, the “system is composed of a structure and of interacting units. The structure is the system-wide component that makes it possible to think of the system as a whole.”⁴⁸ Thus the system is fairly sparse. It is made up of states, which are like units, seeking to survive, without an overarching power to which they can turn for protection. While formal international institutions such as the United Nations and other non-governmental organizations have become the subject of increasing interest within the field of international relations, states remain the primary actors, and the existence of these organizations is often predicated on state involvement and support. The structure of the system “defines the arrangement, or the ordering, of the parts of the system.”⁴⁹ By focusing on the system and the relative distribution of capabilities throughout the system, realist scholars have been able to explain and predict the behavior of states, primarily focusing on the occurrence or likelihood of war, the development and composition of alliances and prospects for cooperation.

We accept the premise that the system places pressures on states and Waltz focuses on two specific forces at work on any given state: competition and socialization.⁵⁰ Both of these forces drive states towards “sameness” insofar as they reward certain behaviors and punish others. States can attempt to dominate their given system, but lacking the necessary capabilities they are likely to fail and suffer the

⁴⁸ Kenneth N. Waltz, *Theory of International Politics* (New York: McGraw Hill, 1979) p. 79.

⁴⁹ *Ibid*, p. 81.

consequences. As European history has shown, quests for dominance by Habsburg Spain, France under the Sun King and Napoleon, and Wilhelmine and Nazi Germany all resulted in their defeat and ultimately their destruction.⁵¹ John Mearsheimer has most poignantly described the tragic nature of world politics in the following way:

The structure of the international system forces states which seek only to be secure nonetheless to act aggressively toward each other. Three features of the international system combine to cause states to fear one another: 1) the absence of a central authority that sits above states and can protect them from each other, 2) the fact that states always have some offensive military capability, and 3) the fact that states can never be certain about other states' intentions. Given this fear – which can never be wholly eliminated – states recognize that the more powerful they are relative to their rivals, the better their chances of survival. Indeed, the best guarantee is to be a hegemon, because no other state can seriously threaten such a mighty power.⁵²

This grim depiction of the struggle states face to survive continues to apply. The U.S. invasion of Iraq, against the desires of the international community reflects the solemn fact that power still matters, and those who wield it can often act as they wish. This concept goes as far back as the writing Thucydides and his analysis of the Peloponnesian War.⁵³ What is clear, however, and has been discussed throughout a variety of realist scholarship is that technology and innovation is a key component of what we consider state power and fluctuations in that power.⁵⁴

How do we begin to understand the role and depict the effects of technology? A purely structural approach would locate technology at the systemic level. It would be

⁵⁰ Ibid, pp. 74-77.

⁵¹ For theoretical analyses of these challenges to the system see for example, Robert I. Rotberg and Theodore K. Rabb (eds.), *The Origin and Prevention of Major Wars* (Cambridge, Cambridge University Press, 1989); Copeland, *The Origins of Major War*, John J. Mearsheimer, *The Tragedy of Great Power Politics* (New York: W. W. Norton & Co., 2001), and Paul Kennedy, *The Rise and Fall of the Great Powers* (New York: Random House, 1987).

⁵² Mearsheimer, *The Tragedy of Great Power Politics*, p. 3.

⁵³ Thucydides, *History of the Peloponnesian War* (London: Penguin Books 1972). See especially page 402.

exogenous, like power, and its only explanatory usefulness would be to differentiate between the relative technological standing of states in the system. Consequently, as many realist scholars would note, relative technological levels would in many cases be conflated with or subsumed by measures of relative power, and thus of little additional analytical value. Conversely, a unit-level approach would more or less place technology and technological change and innovation squarely within the realm of the state. Technology would be an almost completely endogenous variable, based solely upon investment in research and development and public/private sector relationships. As discussed above, this conceptualization is also problematic.

Two important things should be noted when discussing technology in systemic or structural terms. While technological innovations may initially take place within one state, the effects and ramifications of those innovations are often diffused throughout the system in varying degrees and thus influence and shape the technological development of other states. More importantly, the success of states in actually achieving innovation will be, in part, the result of an underlying base of technological know-how available at a given point in time. The uneven development of the modern world is to some degree shaped by this dynamic. The military revolution in Western Europe allowed for the states of a relatively small homogeneous region to conquer and dominate much of the rest of the world during the age of exploration, leading to the creation of vast colonial empires.⁵⁵ However, over time, there is a gradual advance in technology, a qualitative advance that raises the realm of the possible for all actors. When we consider the modern

⁵⁴ Hans J. Morgenthau, *Politics Among Nations, The Struggle for Power and Peace Brief Edition* (Boston: McGraw-Hill, 1993)136-138; Robert Giplin, *War & Change in World Politics* (Cambridge: Cambridge University Press, 1981) pp. 159-162.

state system, we can see that many states are capable of achieving some level of technological prowess, regardless of their relative wealth or power. This process at the global level has taken centuries, while it has been achieved by European states quite rapidly. This would seem to reflect the existence of some sort of technological baseline that exists at any given point in time.⁵⁶ This base is, for intents and purposes, outside of the scope of manipulation by a given state. It delimits what is knowable and what is feasible. The ultimate impact of investment in research and development by any given state, will be a function of this underlying technological baseline, the state's relative technological or industrial prowess (it's own baseline) and the actual efforts made by the state. This concept will be developed further below.

A second important concept in considering technology and the international system is how technology moves from one state to another. There is a large and growing literature on military diffusion. An important concept to note is that, as Geoffrey Herrera has argued, technology is not merely something to be discovered or found.⁵⁷ There often need to be "transmission belts" between innovators and receptor states.⁵⁸ In Herrera's cases, the development of the U.S. atomic bomb and the Prussian railroad network, it is communities of experts that literally carry innovative ideas to states and play an active role in the development of new technological capacities in those states. The development of military-to-military relationships between leading and developing states is a similar path through which expertise and knowledge can be transferred, though in most cases the results are likely to be marginal improvements in training or doctrine as opposed to the

⁵⁵ See for example: Parker, *The Military Revolution*, Chaps 3 & 4; Kennedy, *The Rise and Fall of the Great Powers*, p. 147-169.

⁵⁶ Buzan and Herring, Chap. 2.

dramatic impact exhibited in Herrera's cases.⁵⁹ But there are certainly other ways in which technology and innovation can move from one state to another. Aside from the transfer of expertise and technical assistance, trade is an obvious conduit of technology transfer.

Whether through the trade of military hardware, the "arms trade," or the transfer of (ostensibly civilian or dual-use) technology that facilitates the development of indigenous or organic military-industrial capacities within the client state, trade provides an important potential avenue for states to improve their position relative to others.⁶⁰ The arms trade has often allowed states to improve their position in the short-term, by acquiring and deploying relatively cutting edge weapons systems. Over the longer-term, the client state's ability to develop its own capacities and new systems that support the state's strategic needs within a specific coherent doctrine is often the key hurdle to maintaining a relatively modern fighting force.⁶¹

No state exhibited this pattern better than Imperial Japan.⁶² Shaken from its isolation in the mid-1800s, Japan set out to increase its relative power through the development of a formidable blue-water navy. In its initial stages it attempted to create naval capacities in the short-term by purchasing relatively advanced warships from

⁵⁷ Geoffrey L. Herrera, *The Mobility of Power: Technology, Diffusion, and International Change* (Ph.D. Dissertation: Princeton University, 1995) pp. 25-26.

⁵⁸ *Ibid.* 28

⁵⁹ Herrera examines the development of railroads in Prussia and the development of the atomic bomb in the United States. In both cases, he argues that individuals—railroad engineers from England and scientists from Germany and Eastern Europe respectively—carried the intellectual knowhow and capabilities to their new states necessary to develop these system-changing technologies.

⁶⁰ Over time, the arms trade has increased with other facets of global trade on a number of dimensions, from small arms to larger weapons systems. Buzan and Herring, 42-52.

⁶¹ This highlights the notion between the arms trade and the qualitative spread of technology. In the latter case, states develop increasing capacities of their own to create and develop military capabilities. How successful they are is often an empirical question and will be influenced by their underlying military, technological, and industrial capacities. Buzan and Herring discuss this dynamic in 29-41

Britain, the acknowledged naval leader of the day. It further sought technical assistance and invested in the development of the human capacities necessary to exploit and successfully utilize the new technologies it had bought. The Japanese Imperial Navy that humiliated the Czar's fleet was very much the product of off-the-shelf technology combined with a committed effort to develop the human capital to create a superior naval force.⁶³ The fleet that sailed off to attack Pearl Harbor in December, 1941 was the product of what became an innovative, highly professional naval force utilizing new technologies (naval aviation and the aircraft carrier) provided from what was at the time and organic or indigenous technological capability.⁶⁴ Both were highly effective. But we can clearly see how a state with a certain level of latent or potential power can utilize technology, first off-the-shelf and later produced organically, to create and then maintain first-class military capabilities.

We have also seen examples of the transfer of technology, whether in the form of existing assets or know-how for development, between allies in wartime and at peace. The development of tank warfare as we know it was certainly influenced by the German-Soviet cooperation that took place at the Kazan facilities inside of the Soviet Union during the 1920s.⁶⁵ Two pariah states, shunned by the unsure and fumbling League of Nations, cooperated to develop the concepts that would ultimately lead to both Blitzkrieg and the lesser-known "Deep Battle," the offensive strategy devised by Marshal

⁶² See for example: David C. Evans and Mark R. Peattie, *Kaigun: Strategy, Tactics, and Technology in the Imperial Japanese Navy, 1887-1941* (Annapolis: Naval Institute Press, 1997).

⁶³ Ibid. Chapters 1-4.

⁶⁴ Ibid. Chapter 10. See also Mark R. Peattie, *Sunburst: The Rise of Japanese Naval Airpower 1909-1941* (Annapolis: Naval Institute Press, 2001).

⁶⁵ See for example Mary R. Habeck, *Storm of Steel*, Chapters 3-6. Also see Aleksandr M. Nekrich *Pariahs, Partners, Predators: German – Soviet Relations, 1922-1941* (New York: Columbia University Press, 1997).

Tukachevsky.⁶⁶ Central to both was the idea of independent armored units working within a combined arms framework (with infantry and air power, but capable of rapid, decisive forward attack) to puncture, outflank and encircle stationary or linear defenders. Ironically, the now-legendary battle of Kursk, considered the single greatest tank battle in the history of warfare, which played a major role in reversing the Nazi gains of Barbarossa, was first conceived by German Wehrmacht and Soviet Red Army thinkers at Kazan. We have seen similar sharing of technologies and technological know-how between allies during the Cold War, particularly between Great Britain and the United States.⁶⁷ A desperate Nazi Germany shared many cutting edge technological secrets with Japan in the waning days of the Second World War.⁶⁸ In a less pointed way, France invested significantly in the development Russian railroad systems, ostensibly to facilitate a Russia mobilization against Germany or her allies if a war came.⁶⁹ It should not surprise us that allies, facing a grave threat, would be willing to share new technologies or even breakthroughs if strengthening that ally improved the likelihood of avoiding or winning a possible war. In the first case, two states that had been written off by the international community cooperated in very interesting ways to really transform the battlefield and set the stage for a new kind of war that would be very different from the last.

⁶⁶ On the issue of “Deep Battle” see for instance: Sally W. Stoecker, *Forging Stalin’s Army, Marshal Tukhachevsky and the Politics of Military Innovation*, (Boulder: Westview Press, 1998); Andrei A. Kokoshin, *Soviet Strategic Thought, 1917-91*, (Cambridge: The MIT Press, 1998); and Azar Gat, “Ideology, National Policy, Technology and Strategic Doctrine between the World Wars,” *Journal of Strategic Studies*, 24:3 (September 2000), pp. 1-18.

⁶⁷ See for example Michael Middeke, “Anglo-American Nuclear Weapons Cooperation After the Nassau Conference: The British Policy of Interdependence,” *Journal of Cold War Studies* 2:2 (Spring 2000) pp. 68-69.

⁶⁸ Look for Citations.

⁶⁹ See for example L.C.B. Seaman, *From Vienna to Versailles* (New York: Harper & Row, 1963); James Joll, *Origins of the First World War* (Harlow: Pearson Education, 1992) specifically pp. 153-6.

It is clear that beyond the more general advance of technology, specific technologies can move from state to state through different paths. Whether by diffusion, trade, or the purposeful transfer of capabilities between allies, technology moves throughout the system. In turn, in significant cases, the development of specific technological breakthroughs by states can have system-changing effects. The development of nuclear weapons is one such system-changing development.⁷⁰ While this is an extreme case, it is clear that exploiting new technologies first can have dramatic implications for a given state, its neighbors, and ultimately, the system.

Technological change, and the simple knowledge that technology can change the existing relationships between states, drives states to compete to seek out and harness new technologies. This logic flows directly from Waltz's notion of competition and socialization.⁷¹ States are aware of the opportunities provided to innovators and the dangers that face those who fail to keep up. At the same time, because technology is an inherently difficult concept to assess, states must be vigilant with regard to the activities of their neighbors and potential rivals. Thus technological uncertainty is a fact of life for states attempting to provide for their security in an anarchic system. This is distinct from political uncertainty.⁷² Knowing that rivals may benefit either from the qualitative spread of technology or from the opportunities provided by the arms trade and other avenues of diffusion, states must constantly assess their own technological capacity relative to others.

This dynamic has clearly been at work in the international system since the turn of the twentieth century but can ultimately be traced back to the middle of the 1800s when

⁷⁰ See for example, Robert Jervis, *The Meaning of the Nuclear Revolution*.

⁷¹ Waltz, *Theory of International Politics*, pp. 76.

the industrial revolution “bureaucratized violence” and made all sovereign states active consumers or even producers of military technology. It is little wonder that the first real attempts at cooperative arms control did not take place until the Hague Conferences.⁷³ Until states actually had real control over their investments in technology and became active players in the development of military technology, it made little sense for them to seek out or engage in cooperative measures that would limit or proscribe certain technological applications. Without being able to make credible commitments to other states relative to their development and acquisition of new weapons systems, states had little ability to use military policy to signal benign intentions or reassure wary neighbors.⁷⁴ In a sense, there could be no international arms control before states effectively controlled their arms.⁷⁵ Earlier “arms control” agreements like the Rush-Bagot Treaty signed by the United States and Great Britain after the conclusion of the War of 1812, demilitarizing the Great Lakes, were merely “confidence-building-measures” by modern standards.⁷⁶

⁷² This is distinct from uncertainty of intentions, whether present or future or motives or preferences (actor type). Thus states will find themselves in a more or less constant state of imperfect information when attempting to assess the technological efficacy or developmental levels of others.

⁷³ On the Hague Conferences, please see for example: B.J.C. McKercher, (Ed.), *Arms Limitation and Disarmament, Restraints on War 1899-1939*, (London: Praeger, 1992); A. Pearce Higgins, *The Hague Peace Conferences and Other International Conferences Concerning the Laws and Usages of War*, (Cambridge: Cambridge University Press, 1909); Cavlin DeArmond Davis, *The United States and the First Hague Peace Conference*, (Ithaca: Cornell University Press, 1962).

⁷⁴ Charles Glaser has focused on the ability of states to signal to others through military policies. See, for example, his “Political Consequences of Military Strategy: Expanding and Refining the Spiral and Deterrence Models,” *World Politics* 44:4 (July 1992) pp. 497-538.

⁷⁵ I am indebted to Evan Montgomery for this point.

⁷⁶ See for example Walter LaFeber, *The American Age, U.S. Foreign Policy at Home and Abroad 1750 to the Present Second Edition* (New York: W. W. Norton & Co., 1994) pp.77; Frederick Merk, *The Oregon Question* (Cambridge, 1967).

Technology and the State

Systemic theories often view states as a black box.⁷⁷ The similarity of state goals –the maximization of security or perhaps the maximization of power to best guarantee that security – is a useful simplification for understanding much of world politics.⁷⁸ Definitions of the state may vary, but a basic Weberian approach encompasses most of the important considerations.⁷⁹ Without discussing issues such as regime type, ideology, economic system, ethnic makeup or other factors that may be of interest to scholars of comparative, we can agree that all states must be concerned with their survival. Given that maintaining or improving one’s relative power is the fundamental component of any state’s survival strategy, understanding the nature of that power is worth considering.⁸⁰ How do we understand state power? Realist scholars as well as comparativists have explored this question. The winnowing away of other types of societal organization in Europe leading to the primacy of the nation-state has also been the focus of many

⁷⁷ This would certainly be part of the criticism of liberal scholars who view such variables as regime type, economic structure, worldview, and ideology as crucial to understanding state behavior. Such works of this program would include: Richard Rosecrance and Arthur Stein, “Beyond Realism: The Study of Grand Strategy,” in Rosecrance and Stein (eds.) *The Domestic Bases of Grand Strategy* (Ithaca: Cornell University Press, 1991); Robert O. Keohane and Joseph S. Nye, *Power and Interdependence* (Boston: Little, Brown & Company, 1977); Mark Zacher and Richard Matthew, “Liberal International Theory: Common Threads Divergent Strands,” in Charles W. Kegley, Jr. (ed.) *Controversies in International Relations Theory, Realism and the Neoliberal Challenge*, (New York: St. Martin’s Press, 1995), pp.107-150; and Michael Doyle, “Liberalism and World Politics,” *The American Political Science Review* 80:4 (Dec, 1986) 1151-1169.

⁷⁸ Ultimately, for neorealism, the simplification that all states must concern themselves with their security to insure their survival allows us to consider all states as functionally similar. Using this simplification, relative power (or differentiation of capabilities) is the only defining characteristic of states. See Waltz, *Theory of International Relations*, pp. 95-97.

⁷⁹ Max Weber, *The Theory of Social and Economic Organizations* (New York: The Free Press, 1947) 156.

⁸⁰ Within the realist canon see Morgenthau, *Politics Among Nations*, Chapter 9; and Gilpin, *War and Change*, 3 & 4. More recently, Fareed Zakaria has investigated the nature of “state power” in his analysis of “state-centered realism” in his book, *From Wealth to Power, The Unusual Origins of America’s World Role* (Princeton: Princeton University Press, 1998). In the Comparative Politics literature see for example: Peter B. Evans, Dietrich Rueschemeyer, and Theda Skocpol (eds.), *Bringing the State Back In* (Cambridge: Cambridge University Press, 1985).

investigations.⁸¹ Clearly, technology has played an important roll. It is also clear that the impact of warfare (and the need to prosecute war) on what would become the nation state has played an important (if not decisive or causal) roll, at least in European political development.⁸² Persuasive arguments have also been made that the various revolutions in military affairs have (at the very least) supported the progress of political development in the direction of the nation-state.⁸³ For the purposes of the modern state (and this project) the most important of these was the industrial revolution of the mid-1800s. At this key point, states began the process of truly developing bureaucratic capacities that intervened in the research, development and acquisition of applications of new and emerging technologies and took an active roll toward deploying them to achieve state objectives.⁸⁴ After this period, innovations became more common occurrence.⁸⁵ Where warfare had not change much in the previous two centuries, the late 19th and early 20th centuries would see almost constant, dramatic technological change.

As we have seen throughout the twentieth century, maintaining a technological edge or achieving a technological superiority relative to other states can have grave implications for a state's security. However, as the above discussion of technology's roll and influence at the level of the system should show, technology is not simply an endogenous factor shaped purposefully by the will of a state. What this conceptualization of technology acknowledges is that innovation is not simply a state choice but the

⁸¹ See for example Charles Tilly, *Coercion and Capital*; Hendrick Spruyt, *The Sovereign State and Its Competitors*; Thomas Ertman, *Birth of Leviathan: Building States and Regimes in Medieval and Early Modern Europe*; Richard Lachmann, *Capitalists in Spite of Themselves: Elite Conflict and Economic Transitions in Early Modern Europe*

⁸²Tilly, Otto Hintze

⁸³ See Geoffrey Parker, *The Military Revolution*

⁸⁴ McNeil, *Pursuit of Power*, Chapter 8; Buzan and Herring, *The Arms Dynamic in World Politics*, Chapter 2.

⁸⁵ Buzan and Herring, 11-13.

function of state effort and systemic factors. A state can invest in research and development with the objective of deploying new weapons systems that would ostensibly offer decisive battlefield outcomes. However, whether they actually succeed will be a function not only of their own efforts, but also of the underlying technological environment, which exists at the systemic level.⁸⁶ At the same time, while it may be true that states can choose to invest in the development, acquisition, and deployment of large military forces based upon its relative economic capacities, it may indeed improve its relative military power in quantitative terms. However, the actual overall impact of that choice will involve other factors located outside of the state's control.⁸⁷ It ultimately will be a function of the relative technological (of the qualitative) level of those forces compared to other states' forces to truly determine the new net systemic impact. Thus, while states can choose to attempt to improve their own positions through means that would be considered "internal balancing," the actual effect of that choice is, to a significant degree, outside of their control. The success will be a function not only of their investment and commitment of resources, but the underlying technological base as well as human factors related to the education and training of the military employing the new assets. Thus we need to combine systemic and state level views to really understand how technological change takes place and how its effects are visited upon states and the system.

Technology, the System and the State

A more comprehensive approach would present a technological base located at the systemic level and states would be seen as "plugging-in" to this base in differing

⁸⁶ Buzan and Herring, Chapter 3. Herrera, 26-27.

⁸⁷ Buzan and Herring, Chapter 2-3, Geoffrey Herrera, *ibid.*

degrees of efficiency depending on their relative capability to do so. This capability would be a function of the state's underlying technical-industrial base, economic power, and leadership. Technology would be analytically distinct from simple relative power measurements, but the outputs of research and development and the implications of technological innovation would certainly factor into the state's future relative military capabilities. What is important to note is that states need a certain level of capacity to exploit the existing technological frontier, and even then, their ultimate success will be limited by forces beyond their control.

We can find a useful analogy in neoclassical macroeconomics. The Solow Growth model, which examines the relative development levels of states in terms of an underlying (exogenous) productivity and technological baseline, is useful to consider.⁸⁸ The model depicts the growth trajectory of states based upon the concept of diminishing returns to both capital and labor, the underlying factors of production. States can move "up" or "down" along the curve in the short run, given their levels of investment (subsidies, tax cuts, etc.) to improve their "steady state" of output, but not the long-term growth rate. Forces outside of the states' control, namely technology and productivity, dictate the shape of underlying curve, which depicts the growth trajectory of a given state or states. The nature and shape of the curve itself is exogenous in the sense that it will not change until there is a fundamental change in technology or productivity. The slope of the curve illustrates the fact that after some point, investment will meet with diminishing returns (and depreciation of capital), leading to its S-shape.

[INSERT FIGURE 2 HERE]

⁸⁸ See for example Alan V. Deardorff, "Growth Paths in the Solow Neoclassical Growth Model," *The Quarterly Journal of Economics* 84:1 (Feb. 1970), pp. 134-139.

In the political-military realm, we can expect that states would be supremely concerned with maintaining at least some level of technological prowess relative to their neighbors and potential adversaries. States at the leading edge of the curve would be seen as leaders and innovators in a given system, while those at lower points are less technologically proficient and thus in danger of being victimized by the leaders.⁸⁹ However, if they are actually on the same curve, it is possible, through investment and the commitment of resources to gain ground on the leaders. In such cases, we could also see a strategy of purchasing off-the-shelf technologies from leaders to close a perceived gap. The Solow-curve analogy works especially well for our discussion of technology and innovation in the sense that it reflects what states can and cannot do. Through investment in research and development, states can improve their technological situation in the short-run (along the curve), but any successes will be bounded by what is possible given the underlying exogenous technological baseline (represented by the curve itself). This reflects the crucial aspect of technology and innovation. As Geoffrey Herrera writes:

Technology... is simultaneously a social and technical product. What this means is quite straightforward. Technology obviously is an artifact: a physical thing. As such, it confronts its user as a material fact; a natural part of the physical world. But technology is also the creation of humans and this social in character. While technology may appear to the individual user as unalterable and as natural physical fact, it is also importantly social. It is chosen by some (perhaps_ opaque social process and thus in principle alterable by means of those same processes. There is a tendency to treat technology as a found object: outside the world of the social much like the mountains or the oceans. In turn, this tendency views the discovery of new technologies as the revelation or literal discovery of some part of nature which has heretofore been hidden from man, but is now unveiled. A comfortable middle ground is more likely accurate. Technologies are certainly limited by what is physically possible, and then limited further by the extent of technical knowledge at a particular historical time, but beyond that (and the “beyond” is quite expansive) particular technologies are developed for particular social, economic, political, or personal reasons all of which amenable to analysis by the social scientist.⁹⁰

⁸⁹ Buzan and Herring, 50-51.

⁹⁰ Herrera, 26.

Thus the real utility of the Solow-model analogy is its depiction of the dual endogenous/exogenous components of technology. It captures the plight of states relative to other states and also in relation to the underlying technological base at any given in a particular system (the level of qualitative advance, as discussed above). Thus the curve itself will not change until there is a fundamental change in technology, a breakthrough, that will usually be beyond the manipulation of a given state.⁹¹

In reality, the economic world could be broken into several Solow-type curves, with the great powers primarily clustered on one, middle powers on another, and lesser-developed states on a third. However, in terms of military technology and capability, our curves may look quite different. The United States may be on a curve by itself. China, perhaps India, Japan, the Soviet Union could be placed on a curve somewhat below. Consider the U.S. and the USSR at the end of the Cold War. The announcement of the Strategic Defense Initiative (SDI) and the promise of diverse new technologies created the perception (if not the reality) that the U.S. may very well be moving to a new, higher curve.⁹² The Soviet failure to develop computer technologies was already proving a major obstacle to just keeping up, and after 1983 they risked not only falling behind, but no longer competing at a comparable technological level (see figure 2 below). At the turn of the century, we could see a curve with Great Britain, Germany, and France

⁹¹ The atomic bomb project may be one such case where one state was able to successfully create a “breakthrough” innovation that had system changing implications.

⁹² For the impact that the U.S. commitment to SDI under the Reagan administration had on the Soviet leadership see for example: Jeremy Suri, “Explaining the End of the Cold War: A New Historical Consensus?” *Journal of Cold War Studies* 4:4: (Fall 2002) pp. 60-92.

bunched together at the leading edge, with the United States and Japan somewhat further back and Russia lagging behind (see figure 3 below).⁹³

[INSERT FIGURES 3 & 4 HERE]

Without taking the analogy too far, what should seem intuitive from this depiction of states' relative technological prowess is that states and their leaders will be cognizant of their "place" in the system in terms of their relative military technology. At the same time, they must develop expectations of technological change in order to create logical and coherent strategies. Precisely because of the scarcity of resources, states must make rational, strategic decisions on how to invest in new technologies to best provide for their own security, but this will focus on the future. As mentioned above, the mid-1800s was a key turning point in the notion of the state in terms of its relationship to technology. From the period of industrialization onward, states increasingly became active players in the investment in new technologies, understanding that innovation provided the best protection against the possibility of falling behind a rival. Even states that do not field large militaries can still be seen as possessing latent military power if they possess an underlying industrial-technical base that could allow for relatively rapid development, acquisition and deployment of relatively advanced military assets.⁹⁴ In fact, in a relatively benign system, maintaining a latent (but potentially formidable) military power

⁹³ To be clear – this is not reflective of their developmental levels, but, using the Solow analogy, to reflect the relative technological capacities of these states. This cannot be completely divorced from their underlying developmental levels, but it is only an analogy.

⁹⁴ Buzan and Herring, 50. Japan and modern Germany are both states that have often been considered to be latent or potential military powers given their advanced economies and levels of development.

may be a wiser hedging strategy that fielding largely symbolic forces that could potentially spark concern in other states.

An important point to reiterate, however, is that states do not have infinite resources. Thus, worst-case scenario planning (as would be derived from realist predictions) is simply not feasible for states.⁹⁵ They must make judgments, considering their current and future security environments, and considering the military capabilities that are and will be available to them, on how best to allocate resources to provide for state security. Uncertainty is a fact of life for states and the information that they use to make their decisions will be at best, imperfect. States must view the world probabilistically when it comes to making decisions on the weapons systems they will buy or the types of technological applications that will require investments in research and development to field and deploy.⁹⁶ The “technological imperative,” as Barry Buzan and Eric Herring have called it, has dramatic consequences for states:

The technological imperative exists in the sense that decisionmakers have to consider how to respond to actual and potential technological change. However... it is not simply that technology exists or is invented and then decisionmakers respond rationally to it. Instead, states often initiate technological advance: in crucial ways they shape the development of the technological imperative through their actions and interactions. Indeed, whereas one decisionmaker may see a particular piece of technology as requiring a response, others may not. It is possible that varied responses to the same piece of technology are rational responses to different structural issues.⁹⁷

Given our discussion at this point, we are presented with a world that is fairly reminiscent of the sparse realist world. For the purposes of this project, we can move forward with this systemic or structural realist model of world politics with two additional assumptions that maintain the theory’s explanatory power and parsimony.

⁹⁵ States can’t simply buy all the arms they want or invent all the arms they believe they need.

⁹⁶ If states are rational and strategic and seek to maximize their security they will weight several factors when choosing between these strategies.

⁹⁷ Buzan and Herring, 50.

- **States possess finite resources.** States must allocate scarce resources to provide for their security as well as other important concerns. Therefore, with regard to technological change, states will seek to strategically and rationally invest in new applications.
- **States are active players in the development of new technologies.** This assumption only clarifies the idea that states have the necessary bureaucratic and professional military capacities to actively engage the industrial-technical or commercial entities within their societies to develop, acquire and deploy new technologies.

With these additional assumptions in mind, we begin to develop a model for understanding how states approach technological change and how they develop strategies and engage in behavior to manage not only political but technological uncertainty. We assume that states will seek to maximize their security, but that they will also develop expectations with regard to the military impact of new or emerging technologies. Political and military leaders will likely face tradeoffs and must attempt to find balance between shorter-run and longer run security concerns in the context of technological change.

State will thus be presented with several strategies at any given point in time in terms of how to manage technological change. These strategies are all “ideal types” and in reality, a wise state would likely try to rationally combine these strategies to balance costs, benefits and risks in terms of security and expenditure.

- ***Maintaining*** existing forces with minimal or no technological upgrades would be the effective “do-nothing” strategy, which is certainly possible, but unlikely in a

competitive system. It is cost-effective but threatens the security of the state in all but tranquil security environments.

- **Simple *Updating*** would be a strategy that seeks to make the minimal investments in new technology by purchasing and deploying existing weapons systems, whether from organic sources or through the arms trade, but making little investment in new technologies. This strategy will likely save on costs and is rational if technology is expected to remain relatively stable in the near future, but could undermine the state's security in the face of an innovative neighbor.
- ***Emulation*** would entail the acquisition and deployment of new assets previously deployed by innovating states in order to keep up. The innovator need not be a rival (for geographic or historical reasons) but emulation keeps the state at the leading edge even if it does not develop new doctrine, tactics, or training to fully utilize new military applications.
- ***Modernization*** would similarly see a state purchase and deploy new technologies, but they would be integrated into new doctrinal concepts according to the state's own military needs and strategic objectives. Successful modernization is the most likely strategy to achieve real innovation, but it will be the most costly strategy.

These strategies should be considered separate from state decisions to engage in research and development on new technologies. States can engage in research and development under any of these scenarios, and indeed in a relatively benign security environment, maintaining a latent capability may be a rational choice if more robust steps threatened to create a spiral. They are ideal types that are merely offered to illustrate the tradeoffs involved in the strategic choices that states would likely make relative to military

technology in the context of finite resources in a competitive system. It is important to note that states will develop expectations relative to the impact of new applications of existing or emerging technologies precisely because they cannot have everything. It should not be surprising that states with finite resources may focus their investments in new technologies on specific areas where they may have an objective security need, or where they may have some comparative advantage. Geographic concerns or potential threats may shape both of these factors.⁹⁸ We would expect continental powers to be more concerned with enhancements in the fighting of land warfare while ocean-faring states would be concerned with naval developments.

We would expect that expectations should play a large role in the development of military strategy and consequently the development of state strategy relative to research, development and deployment of new applications of military technology. Similarly, these expectations will shape the willingness of states to engage in disarmament or arms control measures, which offer the potential to improve the security of the state through cooperation rather than through unilateral action that could in fact undermine security by unleashing a spiral. In the next chapter we will explore the role of expectations and their centrality to state strategy with regard to technological change, and specifically their influence on the willingness of states to seek out or agree to cooperative arms control measures.

⁹⁸ In this way, the employment of a balance of threat approach rather than a rougher balance of power approach is probably more precise. Stephen M. Walt, *The Origins of Alliances* (Ithaca: Cornell University Press, 1987).

Figure 1: Sources of Technological Change and their Outputs

