TO WHOM GO THE SPOILS?: EXPLAINING 4,000 YEARS OF BATTLEFIELD VICTORY & DEFEAT

by

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To Victor Fleuter, soldier of the Great War, and survivor of the most horrible thing anyone in my family has ever had to endure.

And to Emma, Lucas, Abby, and Brodie, in the hope that their generation will learn from those previous and leave behind the violent struggles that have accompanied humanity's long existence.

"At Verdun, the combatant fought…in a landscape dismembered by explosives…[where] it was impossible to tell French from German; all were the color of soil." ***Eric Leed***[1]

"Only the dead have seen the end of war." ***Plato***

[1] Cited in Robert O'Connell, in both *Of Arms and Men*, (New York: Oxford University Press, 1990), p255.

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Abstract

The cruel nature of war gives reason for its study. A crucial component of this research aims to uncover the reasons behind victory and defeat. Winning, after all, is the central attraction of organized violence. Unfortunately, political science efforts in this direction have been rare, and the few theories on offer (numerical preponderance, technology theory, and proficiency) are infrequently tested against the empirical record. This dissertation therefore not only subjected the main theories of battlefield victory to a systematic test against the historical record, but also did so with a dataset more comprehensive and with greater chronological breadth than any other in the political science literature. The range of battles included runs from Megiddo (1469 BC) to Wanat (2008).

Such a historically ambitious undertaking is unfortunately fraught with a series of methodological concerns. However, fears regarding the reliability of these historical statistics are best allayed by the assortment of historiographical techniques that have been used to eliminate the more dubious estimations. Concerns regarding data validity are similarly met with a clear delineation of methodological scope: current data is both western-centric and fails to speak to combat in pre-agrarian settings; the conclusions drawn below therefore keep a recognition of these limitations in mind.

Ultimately, the chief findings of this study are that neither Napoleon's 'big battalions' nor armies boasting technological supremacy over their rivals are assured any guarantee of battlefield success. This result is a powerful blow to both mainstream realist theory (whose power calculations rely on raw aggregations like army size) and Western defence planners (who have predicated their strategies on the belief that technology is the chief underpinning of victory). That being said, the most compelling causal explanation for battlefield victory, combat proficiency, appears subject to a crucial caveat: even the most talented armies can be ground into dust. This finding will provide little comfort to gifted armies that find themselves involved in a costly and prolonged campaign, such as Canada and America in Afghanistan. Lastly, this project's contribution should be seen as not only theoretical and practical in nature, but also as providing a methodological toolkit and empirical resource of use to anyone subsequently interested in tracing the evolution of organized violence over time.

In short, this project is summation of how political science thinks about the most basic aspect of war: battle. As the findings of this dissertation suggest, what is distinctly troublesome is that our existing theories and assumptions about who wins and why appear to bear little resemblance to reality. If anything, this dissertation calls attention to the urgent need for further research into the matter of battle victory.

List of Abbreviations Used

AD	Anno Domini.
BC	Before Christ
GDP	Gross Domestic Product.
NATO	North Atlantic Treaty Organization.
RLT	Relative Loss Totals.
SOF	Special Operations Forces.
UAV	Unmanned Aerial Vehicle.

Acknowledgements

I come from a long line of agricultural stock. We are a family of farmers, not warriors. And yet to look at the 20th century, one might be persuaded otherwise. Here a succession of my ancestors participated in some of the most seminal conflicts our civilization has ever known. Given the bloodiness and brutality of these struggles, it is miraculous that they all survived. As any good student of military history knows, life passes easily into death on the field of battle. To escape this fate, they must have relied on good fortune—but also courage. After all, survival requires a singular strength. How this line of men stood up to the fury of war, a force so pitiless and cruel, is unfathomable to those of us who have only known peace. Yet on with their duty they went, no matter how difficult the transformation from pioneer to rifleman must have been.

This puzzling display is the origin of my intellectual curiosity toward military affairs. The world would be much better off, of course, if farmers were left to tend crops and raise herds of livestock, rather than being sent off to kill in the name of king and country. But as with any project of this magnitude, my interest alone is insufficient. I have instead relied heavily on the warm encouragement and sound advice of others. Kim Lawton, Lara Spagrud, Kathleen Foran, and Ted Aubut all read elements of what follows in a very nascent form. Their comments did much to set up the project and get it moving forward. Similarly important at an early stage were Kalowatie Deonandan, Joshua Goldstein, and Gilles Duranton. Their support and contributions to my graduate education have not been forgotten.

Thanks are also owed to my PhD cohort at Dalhousie. Dave McDonough, Anita Singh, Alex Wilner, Dave Perry, and Sabrina Hoque could always be counted on to offer wisdom and insight when requested, and a good night out in Halifax when needed. Eric Lerhe, for one, never

let a table suffer for lack of wine. In the department, Karen Watts proved a reassuring rock in a sea of the bureaucratic wrangling that so characterizes an academic institution. Without her, no trains would run on time. The faculty was similarly patient and kind. Jennifer Smith provided me my first opportunity to teach, which Robert Finbow subsequently encouraged. I am similarly indebted to both Denis Stairs, ever the quintessential gentleman, and Danford Middlemiss, a man who takes more notes than I do, for their consistent encouragement and insightful observations. So too am I grateful to Frank Harvey, who blurs the lines between colleague, mentor, and friend with the artistry of a French impressionist; and Brian Bow, for his endless and unerringly helpful answers to my ceaseless questions, and for his role as my staunchest advocate. You have all taken whatever knowledge and skills I may have had, and made me into a true social scientist.

Lastly, I must thank Russell Isinger, for leaving me enthralled with the notion that my love of history, passion for politics, and fascination with economics could fall under the same professional umbrella; and the Social Science and Humanities Research Council, which made my education financially possible. My parents played a vital part in this project as well. Dad taught me long ago that a balanced view is always closest to the truth; while Mom, editor extraordinaire, proves every day that an economist need not be unloved.

Chapter 1: Introduction

1.1 Project Rationale

It is uncertain when the first war took place, but its effects can surely be surmised, for even the tamest of battles instill fear, apply violence, and draw blood. At their most extreme, the costs exacted stagger the imagination. An officer of the 24th Panzer Division, witness to the ferocious fighting around Stalingrad in October 1942, describes just how relentless these struggles can be:

> "We have fought for fifteen days for a single house with mortars, grenades, machine-guns and bayonets. Already by the third day fifty-four German corpses are strewn in the cellars, on the landings, and the staircases. The front is a corridor between burnt-out rooms; it is the thin ceiling between two floors. Help comes from neighbouring houses by fire-escapes and chimneys. There is a ceaseless struggle from noon to night. From storey to storey, faces black with sweat, we bombed each other with grenades in the middle of explosions, clouds of dust and smoke…Ask any soldier what hand-to-hand struggle means in such a fight. And imagine Stalingrad; eighty days and eighty nights of hand-to-hand struggle, blinding smoke; it is a vast furnace lit by the reflection of flames. And when night arrives, one of those scorching, howling, bleeding nights, the dogs plunge into the Volga and swim desperate to gain the other bank. The nights of Stalingrad are terror for them. Animals flee this hell; the hardest storms cannot bear it for long; only men can endure."[2]

Amidst such carnage, life and death become almost meaningless. In the words of Guy Sajer,

[2] Cited in John Keegan, *Second World War*, (London: Hutchinson, 1989), p231.

another veteran of World War II's brutal Eastern Front, "I had learned that life and death can be so close that one can pass from one to the other without attracting any attention."[3] In war the living are perpetually surrounded by death. In a January 1917 letter, Wilfred Owen described to his sister how such macabre conditions reigned on the Western Front. "I have not seen any dead," he wrote. "I have done worse. In the dank air I have *perceived* it, and in the darkness, *felt* it…No Man's Land under snow is like the face of the moon: chaotic, crater-ridden, uninhabitable, awful, the abode of madness."[4]

To be sure, soldiers have no monopoly on suffering. Wars invariably spill beyond the battlefield and taint the surrounding population with its toxic mix of death and destruction. Such actions are often the result of deliberate policy to terrorize or plunder the local population. An eyewitness to a 13thC English pillaging raid in France records such an operation:

> "The march begins. Out in front are the scouts and incendiaries. After them come the foragers whose job it is to collect the spoils and carry them in the great baggage train. Soon all is tumult. The peasants, having just come out to the fields, turn back uttering loud cries. The shepherds gather their flocks and drive them toward the neighbouring woods in the hope of saving them. The incendiaries set the villages on fire and the foragers visit and sack them. The terrified inhabitants are either burned or led away with their hands tied to be held for ransom. Everywhere bells ring the alarm; a surge of fear sweeps over the countryside. Wherever you look you can see helmets glinting in the sun, pennons waving in the breeze, the whole plain covered in horsemen. Money, cattle,

[3] Guy Sajer, cf Stephen G. Fritz, *Frontsoldaten: The German Soldier in World War II*, (University of Kentucky Press, 1997), p69.
[4] M.J. Cohen and John S. Major, *History in Quotations: Reflection 5000 Years of World History*, (London: Cassel, Orion, 2008), p715.

mules and sheep are all seized. The smoke billows and spreads, flames crackle. Peasants and shepherds scatter in all directions."[5]

Many such transgressions against the civilian population have been the result of a calculated policy of terror. It was, for example, not unusual for the ancient Assyrians to kill every man, woman and child in a captured city, or to carry away entire populations into captivity—all the better to frighten their opponents into submission.[6] As Gaul fell to barbarian invaders in the early 5th century AD, merciless ruin was left in their wake. "Throughout settlements and estates, throughout fields and cross-roads and every district, on every road this way and that, there was death, sorrow destruction, burning, lamentation. All Gaul smoked like one great funeral pyre."[7] After Tamburlane's sack of Delhi in 1398, the city was left so ruined that, according to an eyewitness, "for two whole months, not a bird moved a wing in the city."[8] In modern times, too, cries of fear and pain often follow vanquished civilian populations as the victors rape and pillage their way across conquered soil.[9]

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[5] *Chansons des Lorrains*, 13thC French epic poem. Translation, J. Gillingham. Cited in Richard Holmes, *World Atlas of Warfare*, (Markham, ON: Viking, 1988), p41. An earlier, though similarly chilling, description comes from Sennacherib of Assyria's boast following his sack of Babylon in 680 BC: "I leveled the city and its houses from the foundations to the top, I destroyed them and consumed them with fire. I tore down and removed the outer and inner walls, the temples and the ziggurats built of brick, and dumped the rubble in the Arahtu canal. And after I had destroyed Babylon, smashed its gods and massacred its population, I tore up its soil and threw it into the Euphrates so that it was carried by the river down to the sea." Cited in Gwynne Dyer, *War*, (New York: Crown Publishers, 1985), p4. See further, James Wellard, *By the Waters of Babylon*, (London: Hutchinson, 1982), p147.

[6] Trevor N. Dupuy, *The Evolution of Weapons and War*, (Da Capo Press, 1990), p7-8.

[7] Orientius, *The Admonition*, 2.165-84.

[8] Cited in Holmes, *Atlas*, p61.

[9] The Greek sack of Troy offers a typical example of this (though told by Virgil in likely apocryphal—but accurate—terms): "An ancient city was falling and the long years of her empire were at an end. Everywhere the dead lay motionless about the streets, in the houses, and on these temple stairs which our tread had reverenced so long….The Greeks were dashing to the [palace], and thronging round the entrance with the shields locked together over their backs; ladders were already firmly in place against he walls, and the attackers even now putting their weight on the rungs near the door-lintels. Holding shields on their left arms thrust forward for protection, with their right hands they grasped the roof. To oppose them the Trojans, on the brink of death and knowing their plight was desperate, sought to defend themselves by tearing up tiles from the roof-tops of houses…to use as missiles….Inside the palace there was sobbing and a confused and pitiful uproar. The building rang from end to end with the anguished cries of women." Virgil, *The Aeneid*, W.F. Jackson Knight (trans), (London: Penguin Books, 1968), p62-65. Another is the Roman sack of Cremona in 69 AD: "Forty thousand men forced their way in to the city….Neither rank nor years saved the victims from an indiscriminate orgy in which rape alternated with murder

The Neglected Causes of Victory

With such brutal effects, it is unsurprising that organized violence is subject to careful study. War has, in fact, traditionally been a state's foremost concern. This attentiveness is rarely born of moral considerations. Instead, it reflects the fact that political conditions are the echoes of military contests. At the extreme, failure in war can bring about a state's extinction.[10] As Stalin, a man with much experience in such matter, observed: "whoever occupies a territory also imposes on it his own social system."[11] What came before is tossed to the wind by the victors—or worse. Indeed, as defeated leaders from Valens to Saddam can attest, many an unlucky prince lost his head after defeat on the battlefield. When the Romans stormed Carthage in 146 BC at the end of the Third Punic War, they ruthlessly sacked the city, burned it to the ground, enslaved whoever remained of the city's original 300,000 inhabitants, and sprinkled salt on the ground.[12] Given that defeat in war is the most common reason why states disappear, Livy was correct to lament "woe to the vanquished!"[13]

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and murder with rape. Greybeards and frail old women, who had no value as loot, were dragged off to raise a laugh, but any full-grown girl or good-looking lad who crossed their path was pulled this way and that in a violent tug-of-war between the would-be captors….A single looter trailing a hoard of money or temple-offerings of massive gold was often cut to pieces by others who were strong….In their hands they held firebrands, which, once they had got their spoil away, they wantonly flung into empty houses and rifled temples….There was a diversity of wild desires, differing conceptions of what was lawful, and nothing barred. Cremona lasted them four days." Cornelius Tacitus, *The Histories*, Kenneth Wellesley (trans), (London: Penguin Books, 1982), p165. The rest of the Italian peninsula was shocked by this, for this happened to an unarmed Roman city, with the crimes perpetrated by *Roman* legions during Civil War.

[10] A fact first observed by Sun Tzu, in his *Art of War*, Samuel B. Griffith (trans. and intro.), (New York: Oxford University Press, 1971). Raymond Aron echoed this with this assertion that "The stakes of war are the existence, the creation or the elimination of states." Aron, *Peace & War: A Theory of International Relations*, (New Brunswick, NJ: Transaction Publishers, 2003 [1966]), p7.

[11] Joseph Stalin to the Yugoslav Milovan Djilas, 11 April 1945. Cited in Cohen and Major, *Quotations*, p854. Such sentiment goes back at least to the 1648 Treaty of Westphalia, and its *Cuius regio, eius religio* ('Whoever rules the territory imposes his religion').

[12] The eyewitness account of Polybius has unfortunately been lost to history. However, Appian's (bloody) account is directly based on it. See Susan Rowen, *Rome in Africa*, (Evans Brothers, 1969).

[13] Titus Livius [Livy], *Ab urbe condita libri* [*History of Rome*], (~27-25 BC): Book V, sec. 48. The original Latin is *Vae victis!*

More to the point, however, is that these political transformations—executions of an existing elite, implementation economic order, and so forth—are possible because military power is "ultimately the power to destroy and kill, or to occupy and control, and hence to coerce."[14] Coercion, in turn, is the most basic form of resolving political difference. Losing therefore comes at a steep political price: the vanquished must now accepted the dictated terms, no matter how brutal.[15] Meanwhile, the corollary to the misfortune of defeat is the wealth and prestige of conquest. Some of history's most successful civilizations—the Romans, the Han, the Ummayads—were predicated on consistent battlefield success. As long as the mighty legions kept adding new territory and slaves to the Empire, Roman coffers stayed filled to the brim.[16] In fact, prior to the industrial revolution, no state policy was better suited to accumulating economic surplus than military conquest. No wonder so many leaders have considered the matter of war their primary concern.

There are other reasons to study war as well. Some study war because its heroism and terror give rise to an abiding fascination. "Throughout history, for every person who has expressed his horror of war there is another who found in it the most marvelous of all the experiences that are vouch-safed to man, even to the point that he later spent a lifetime boring his descendents by recounting his exploits."[17] More succinct was Robert E. Lee: "It is well that war

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[14] Klaus Knorr, "The International Purposes of Military Power," in J. Garnet (ed), *Theories of Peace and Security*, (London: Macmillan, 1970), p50.

[15] A lamentation over the destruction of Ur in 2000 BC captures this shocking detail:

> "How, O Sumer, are they mighty fallen!
> The holy king is banished from his temple.
> The temple itself is destroyed, the city demolished.
> The leaders of the nation have been carried off into captivity.
> A whole empire has been overthrown by the will of the gods."

Wellard, *Babylon*, p101.

[16] Agriculture comprised 3/5s of the Roman economy during the reign of Augustus. Raymond W. Goldsmith, *Premodern Financial Systems: A Historical Comparative Study*, (Cambridge: Cambridge University Press, 2008 [1987]), p35. The Roman concern with land is therefore unsurprising.

[17] From Martin van Creveld's *Transformation of War*, cited in Phil Williams, *et al*, *Classic Readings and Contemporary Debates in International Relations*, (Belmont, CA: Thomson Wadsworth, 2006), p618.

is so terrible—otherwise we would grow too fond of it."[18] On the other hand, war is often studied out of sheer bafflement. The descent of affluent, cooperative societies into ruthless exponents of systematic slaughter has provided ample fodder for the intellectually curious. Europe of 1914 provides a case in point. It is bewildering to consider a continent so rich and resplendent, and yet as self-destructingly belligerent as the Athenians were before Syracuse (415-413 BC). But a more important impetus is the desire to eradicate this scourge altogether. "I must study politics and war," John Adams argued, "that my sons may have liberty to study mathematics and philosophy."[19] The study of war does not lack good reason.

Given this confluence of motives, it is unsurprising that war has been the subject of innumerable studies by historians, political scientists, and psychologists.[20] Even in contemporary times—an era characterized by relative peace—books on war dominate bestseller lists.[21] Quantity, however, offers no assurance of comprehensiveness. Despite all this ink spilt, the study of war is notably incomplete. "Of war men will ask its outcome, not its cause."[22] Thus was the contention of Seneca the Younger. Yet while this may be true for those nervously awaiting the fates of loved ones in battles far away, the bulk of scholarly efforts have instead been in a very different direction. In fact, although a great and varied literature investigates the various *causes* of war,[23] comparatively little work has been done to understand the important

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[18] Statement at the Battle of Fredericksburg (13th December 1862).
[19] Quoted in Gordon Craig and Alexander George, *Force and Statecraft: Diplomatic Problems of Our Time,* (Oxford: Oxford University Press, 1995), p193.
[20] See, for example, the typologies in Bernice A. Carroll and Clinton F. Fink, "Theories of War Causation: A Matrix for Analysis," in Martin A. Nettleship et al (eds), *War, its Causes and Correlates*, (The Hague: Mouton, 1975), p55-71.
[21] As of October 21, 2010, Amazon.com's history top-20 list included two formats of Bob Woodwards' *Obama's War*, two formats of a biography of (general) George Washington, a history of the Soviet Union and Nazi Germany's mass-killing apparati, and a history of the AK family of assault rifles.
[22] Seneca, *Hercules Furens*, (1st C AD): Lycus, 397. See John G. Fitch (ed), *Seneca's Hercules Furens: A Critical Text with Introduction and Commentary*, (Ithaca: Cornell University Press, 2009). Seneca was an accomplished Roman statesman, philosopher, and playwright—and also a tutor of Nero.
[23] For surveys of this literature, see Michael Howard, "The Strategic Approach to International Relations," *The Causes of Wars*, (Cambridge, MA: Harvard University Press, 1983); Greg Cashman, *What Causes War? An*

question of why some belligerents win and others do not. Rather than a systematic evaluation of the causes of victory, outcomes are more frequently ascribed to the intervention of kindly providence or cruel fortune. Contemporaries to the destruction of Ur in 2000 BC explained that the "empire has been overthrown by the will of the gods."[24] Faced with frustration in his attempt to cross into Asia Minor, Xerxes is said to have had the sea flogged.[25] Even the meticulous Romans chalked up military defeat as a sign that the gods did not find justice in their cause. Nor has this tendency disappeared. "Most studies of war and other forms of social conflict focus on the causes and conditions of these phenomena."[26] How and in whose favour such conflict is resolved is still a matter left beyond consideration. Put more precisely, while there exists "a voluminous literature that examines [war's] causes, patterns of outbreak, waging, and impact on the international system,"[27] rarely considered are the persistent, causal forces behind victory and defeat.

So while it is common to talk about war, the determinants of military outcomes are decidedly understudied. Of this research imbalance both historians and political scientists stand accused. For the former, "comparatively few historians have focused on the issues of victory and defeat in war."[28] This is to be expected, given the wariness historians hold towards the search for generalizable models. "Prefabricated systems," Barbara Tuchman wrote, "make me

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Introduction to Theories of International Conflict, (New York: Lexington Books, 1993); Stephen van Evera, *Causes of War: Power and the Roots of Conflict*, (Ithaca: Cornell University Press, 1999); Dougherty and Pfaltzgraff, *Contending Theories of International Relations*, chpt 5-9; and Jack S. Levy, "The Causes of War and the Conditions of Peace." Annual Review of Political Science, 1 (1998): 139-66. Good readers to go alongside these texts include Michael E. Brown (ed), *Theories of War and Peace*, (MIT Press, 1998); Richard K. Betts, *Conflict After the Cold War*, (Longman, 2008); and David Sobek, *The Causes of War*, (Cambridge: Polity Press, 2009).

[24] Wellard, *Babylon*, p101.

[25] Cardwell, *Clocks*, p15.

[26] Hugh Wheeler, "Postwar Industrial Growth," in *Correlates of War: II*, p258.

[27] John Arquilla, *Dubious Battles: Aggression, Defeat, and the International System*, (Washington: Crane Russak, 1992), pvii.

[28] Brian Bond, *The Pursuit of Victory: From Napoleon to Saddam Hussein*, (New York: Oxford University Press), p1.

suspicious and science applied to history makes me wince."[29] For historians, patterns are almost impossible to unveil—if they even exist at all. The consequence of such an emphasis on particularized circumstances is that historians do not care much for models and predictions.[30]

There is more at play here, however, than an aversion to model building. Although mainstream political science is deeply enamored with positivism and its search for causal patterns, it has nonetheless been similarly timid, offering little discussion on the causes of victory and defeat, and subsequently very few testable explanations. As Martel observes,

> "The problem immediately confronting a study of victory is that there is no formal theory of victory; the prevailing ideas about victory, developed over the millennia, are based on the loosely formed but universally held premise that the state organizes its strategy and resources to defeat and, ultimately in some cases, to annihilate another state in war. Yet there is no formal or analytical relationship between victory and strategy, and the concept of victory has been subordinated in the literature to the principles of strategy and the practice of diplomacy."[31]

In other words, the search for victory has been left to the practical realm. Rather than having the academy try to elucidate some common pattern of what it takes to win, the matter of victory has been to the diplomats and generals. It is as if war is seen as being too serious to be left in the hands of academics.

This absence of theorizing about victory is well reflected in the literature. Dougherty and Pfaltzgraff's exhaustive survey of international relations theory, for example, offers no section

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[29] Barbara Tuchman, *Practicing History*, (New York: Knopf, 1981), p22.
[30] See, for example, Pierre Renouvin and Jean-Baptiste Duroselle, *Introduction to the History of International Relations*, Trans. Mary Ilford, (New York: Frederick A. Praeger, 1967), p376.
[31] William C. Martel, *Victory in War: Foundations of Modern Military Policy*, p84. As Martel continues, "There have been discussions about victory," such as Alger's *The Quest for Victory*, "but no explicit theory of victory." p331-32, fn#10.

on military victory and defeat.[32] Neither do the first or second volumes of the *Handbook of War Studies*.[33] The *New Handbook of Political Science* makes no mention of battles or military victory (though it does speak to war causation).[34] The *Oxford Handbook of International Relations* and the *Handbook of International Relations* are similarly silent.[35] Stephen Van Evera's "Offense, Defense, and the Causes of War" is the only piece in Michael Brown *et al*'s *Theories of War and Peace* to explicitly deal with how and why some belligerents win and others lose—and this only describes the factors which increase the "ease" with which conquest occurs, which in turn determines how likely war is to break; the discussion is not, however, a concerted theory of victory. [36] Even when the matter of victory is brought up, such as in the towering works of Morgenthau and Waltz,[37] theories of victory are proposed haphazardly at best—and are certainly not subjected to concerted empirical test. More broadly, realism tends to assume that the "distribution of power will heavily determine when fighting occurs, who will side with whom, and who will win,"[38] and then leave the explanation at that. How this maxim is to be interpreted is left to reader's own devices.

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[32] James E. Dougherty and Robert L. Pfaltzgraff, *Contending Theories of International Relations: A Comprehensive Survey*, (Longman, 2000).
[33] Manus Midlarsky (ed), *Handbook of War Studies*, (Boston: Unwin Hyman, 1989); and Manus Midlarsky (ed), *Handbook of War Studies II*, (Ann Arbor: University of Michigan Press, 2000).
[34] Robert E. Goodin and Hans-Dieter Klingemann (eds), *A New Handbook of Political Science*, (Oxford: Oxford University Pres, 1998).
[35] Christian Reus-Smit and Duncan Snidal (eds), *Oxford Handbook of International Relations*, (Oxford: Oxford University Press, 2008); Walter Carlsnaes, Thomas Risse, and Beth A. Simmons (eds), *Handbook of International Relations*, (Los Angeles: Sage, 2001). Jack S. Levy's "War and Peace" chapter in the latter, for example, surveys the subfield of war studies and finds three main "things we want to explain: the constant recurrence of war, variations in war and peace, and the origins of particular wars." (p351).
[36] Michael E. Brown, Owen R. Coté, Jr., Sean M. Lynn-Jones, and Steven E. Miller (eds), *Theories of War and Peace*, (Cambridge: MIT Press, 1998, p55-93. Van Evera's discussion of the feasibility of conquest takes place from p66-72, and considers technological, doctrinal, strategic, geographical, sociopolitical, and diplomatic factors in turn. As the book's preface suggests, the volume's chief interest is in the causes of war and peace.
[37] Hans Morgenthau, *Politics Among Nations,* (New York: Knopf, 1973). Kenneth Waltz, *Theory of International Politics*, (Reading: Addison-Wesley, 1979).
[38] John Arquilla, *Dubious Battles*, (Washington: Crane Russak, 1992), p10.

Some suggest that the tendency for theoreticians to shy away from the practical matters of winning and losing is a good thing. "Actually, in matters of business and affairs of state," warned Pope Clement VIII in August 1595, "there is never any need to avail oneself of the work of academics [*dottori*] since with their excessive subtleties they are more likely to ruin them than bring them to a good conclusion."[39] The reason is, as the Italian Ludovico Zùccolo complained, "He who has not ploughed the sea does not presume to know the art of navigation."[40] Indeed, comparatively few in the ivory tower have ever seen frontline service. Few scholars know what it is like to lie huddled in a trench, cloaked in mud and uncertainty, fearfully awaiting the coming dawn. Why, then, should armchair generals see themselves fit to speak of such matters?

In this case boldness is a virtue, for there are, in fact, several reasons why it is worth theorizing about the more practical aspects of military affairs. Foremost is, as described above, Clausewitz's observation that war is nothing more than the extension of politics.[41] As every conquered people soon learn, the winners of military contests impose their political framework on the vanquished even before the guns go silent. For this reason the great Prussian wrote that "War is only a branch of political activity; it is in no sense autonomous…[It] cannot be divorced from political life."[42] Politics and war are inextricably bound. Any study of politics must therefore consider this fundamental means of conflict resolution, both in regard to the origins of existing political orders, but also as the final arbiter of disputes, current and future, that cannot be resolved by alternative means. In other words, political scientists should care about who wins

[39] Cited in Jonathan Haslam, *No Virtue Like Necessity: Realist Thought in International Relations Since Machiavelli*, (New Haven: Yale University Press, 2002), p1.
[40] Cited in Haslam, *Necessity*, p2. Zùccolo was writing in 1621.
[41] It is "a clash between major interests that is resolved by bloodshed—that is the only way in which it differs from other conflicts." Carl von Clausewitz, *On War*, trans. and ed. Michael Howard and Peter Paret (Princeton, N.J.: Princeton University Press, 1976), p149.
[42] von Clausewitz, *On War*, Book VIII, Chapter 6B, 'War is an Instrument of Policy.' He continued, arguing that "whenever this [disconnection between war and politics] occurs in our thinking about war, the many links that connect the two elements are destroyed, and we are left with something that is pointless and devoid of sense."

and how because victory affects political circumstances. Very few borders, for example, are drawn without some reflection of a previous military result. Any theory of politics is incomplete without reference to how such conditions are formulated in the first place.

Consider the case of Prussia. By the time Frederick William, the Great Elector of Brandenburg, passed away in 1688, the humble foundations of the Prussian state had been molded: a population of roughly 1.5 million and an army of just 18,000. A few decades later there was still "little to distinguish Prussia from other fair-sized German states with rulers imitating Louis XIV—court etiquette, architecture, extravagance, impending bankruptcy."[43] Yet from this modest beginning, a succession of martial leaders—including Frederick William I, Frederick II, Kaiser Wilhelm I—oversaw the rise of what would become Germany, in 1871, to the very heights of the European political order. The binding together of the Germanic states has left Germany in a dominant position even today, in fact. Any scholar interested in politics must recognize that a crucial element to this story has been persistently favourable outcomes on the battlefield. There were many pretenders, let us remember, to German supremacy. As such, to understand how and why Prussia was capable of these feats is a vital precursor to a useful explanation of German politics.

A proper understanding of the dynamics behind victory is important to the matter of war initiation as well. This is because a belligerent's relative prospects play a crucial role in determining whether or not violence breaks out in the first place.[44] The mere appearance of a likely victory can make war palatable, if not eagerly desired. The problem, however, is that "in

[43] Cited in Ropp, *Modern*, p45. Ropp himself notes that "Modern Prussia was really the creation of a very able ruling family, who worked well with the materials they had at hand to create both a state and an army." (p44-45).
[44] As Levy writes, "to understand war we must understand why decision-makers choose military force rather than other means to achieve their desired ends." Jack S. Levy, "War and Peace," in Carlsnaes *et al*, *Handbook*, p350. Wars, we must remember, are ultimately fought because somebody thinks they can win.

at least fifty per cent of the cases they [the losing army] got a result they did not expect."[45] Somewhere along the line the calculations went awry. Any desire to understand the decisions behind the choice of war therefore requires uncovering how these calculations are made and, better yet, how accurate their conclusion are. Suppose, for example, the models policymakers use to determine the chances of winning underestimate the risk inherent in such a strategy. Knowledge of this might provide some calm during the deliberations behind war. A better understanding of who is likely to win and why will of course do little to dissuade the favoured from trying their hand on the battlefield. But it will certainly give pause to those who once harboured false hope.

The third reason is perhaps more basic. When confronted with the inexplicable, humans have traditionally chalked up the phenomenon to mysticism, religion, or chance. In so doing, hope for human agency is replaced by faith that the gods will find favour and spare their caprice. Throughout history societies have devoted shamans and high priests to the issues of weather and death in precisely this manner. War is also viewed in such terms. In fact, it is frequently deemed a Sorcerer's Apprentice: an instrument summoned to provide assistance, yet one inherently unmanageable and prone to calamity once released. The problem which such thinking is that the ignorance and uncertainty which surround war are taken to absolve leaders, both military and civilian, from their responsibilities in such an unpredictable affair. Once the dragon is unleashed, such thinking goes, who can be expected to tame it? Yet unless war is a matter of purely chaotic indeterminism, there must be distinct causal—and therefore somewhat

[45] Michael Howard, *The Causes of Wars*, (London: Unwin, 1983), p12. It is fair to say, however, that not all armies are convinced they are likely to win. They just feel that they are better off going to defeat whilst fighting, rather than enduing a straight capitulation. As Blainey notes, the choice of violence is a conscious decision made by *both* parties; every participant inherently feels there is more to gain from fighting than remaining at peace. If they did not, they would not pick up arms. Geoffrey Blainey, *The Causes of Wars*, (New York: Free Press, 1988 [1973]), p135.

predictable—forces at play. This is not to downplay the obfuscatory tendency of Clausewitz's "fog"; enough armies have got lost in the dark to put paid to that. But it is quite unlikely that winning and losing are governed solely by the laws of chance. It is therefore erroneous to assume that when leaders, to use Bethmann-Hollweg's phrase in 1914, "roll the iron dice", the fates of nations are determined by happenstance and sheer luck. In contrast, these dice are generally loaded.[46] And it is worth considering in what ways, because at minimum, the dejected ignorance that accompanies the decision to war is simply not good enough, and at most, because the problem with ignorance is that it leads to an abdication of responsibility.[47]

Lastly, the dearth of theory regarding military victory is unfortunate because in the absence of clearly defined theory, there can be no learning. Lacking a hypothesized pattern, there can be no test to see if such an assumption is right or wrong. Missing that, there can be no hope of fulfilling Thucydides' great ambition: "if these words of mine are judged useful by those who want to understand clearly the events which happened in the past and which (human nature being what it is) will, as some time or other and in much the same ways, be repeated in the future."[48] The past has something to teach the future, but we can only uncover these lessons with a systematic search for consistent causal trends. Outside this the errors of the past are free to be repeated—a fact which is deeply

disturbing, given the horrifying stakes involved that accompany the descent into war.

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[46] The 'fog' analogy is from Clausewitz, *On War*. Clausewitz himself tended to look at the matter of victory and defeat in war as a "game of cards." von Clausewitz, *On War*, (1976), p86.

[47] Hollweg, for example, feared the coming war in 1914 would lead to "the overthrow of everything that exists." Yet this did not temper his willingness to argue that it was the best alternative available to Germany at the time. See S. Förster, "Dreams and Nightmares: German Military Leadership and the Images of Future Warfare, 1871-1914," in M.F. Beomeke, Roger Chickering, and S. Förster (eds), *Anticipating Total War: The German and American Experiences, 1871-1914*, (Cambridge, 1999), p364-5, 373; Holger H. Herwig, "Germany and the 'Short War' Illusion: Toward a New Interpretation?", *Journal of Military History*, 66 (July 2002), p692.

[48] Thucydides, *History of the Peloponnesian War*, M. Finley (ed), (London, 1872), I.22.4, p48.

Lonely Theories in Need of Testing

These reasons make it abundantly clear that the current paucity of theorizing about victory is unacceptable. This is not to suggest, however, that *no* attempt has been made to look for causal patterns in battle outcomes. Dearth must not be confused with total absence. As we shall soon discuss, there are indeed separate bodies of distinct thought regarding who wins military contests and why. Unfortunately, the few theories that actually address this topic are not satisfactory either. Indeed, even when the causes of victory and defeat are considered, the theorizing tends to be frustratingly vague or incomplete. The conclusion of John Alger's exhaustive survey of victory theories, for example, relies on the Soviet army's advice that "In order to gain victory, it is necessary to concentrate decidedly superior forces for the main effort by a regrouping of forces and combat means."[49] Whether or not this 'superiority' is to come from material preponderance, combat proficiency, or military technology amenable to either offensive or defence force postures is left to the reader's interpretation. Policymakers are thus left with little notion of which strategy offers the most productive use of a nation's finite resources. And yet Alger's work is more explicit than most. Take realism. Proponents of balance of power theory generally fail to articulate the logical implication of their materialist assumptions, at least vis-à-vis victory. If numbers are given causal priority in a parsimonious theory, the conclusion should be that superior numbers bring victory on the battlefield. But rarely is this conclusion drawn, let alone subjected to empirical test.

With these concerns in mind, the over-arching concern of this dissertation is to rectify such shortcomings. In the chapters that follow, hypotheses for each of the major schools of thought regarding the age-old question of '*who wins and why*' have been explicitly drawn. Three

[49] John Alger, *The Quest for Victory: The History of the Principles of War*, (Westwood, CT: Greenwood, 1982), p134, citing U.S.S.R., People's Commissariat of Defense, *Field Service Regulations*, Charles Berman (trans), p1-2.

such theories currently exist, and each will be considered in turn. The first and most common argument is that of numerical preponderance, which assumes that victory goes to the side with greater material resources. This assumption lies inherent in much of the current international relations literature on power and interaction between states. The second chapter will consider technology theory, which argues that victory is a reflection of the relatively distribution of technology. Such thinking dominated NATO's preparations during the Cold War and buttresses the claims of contemporary 'Revolution in Military Affairs' (RMA) theorists. Last is the theory which political science considers least: proficiency. This is the oft-overlooked assertion that the winners of military contests are those armies more capable than their adversaries. For better or worse, these theories constitute the basic outlines of current thinking on the causes of battlefield victory.

Each theory is considered in a separate chapter. All begin with a detailed discussion of the relevant literature, including both the hypothesis' origins and central predictions. Following this, each prediction has been confronted with some 3,500 years of systematically marshaled battle data. Variables included in this effort are force size, national wealth, strategic posture (offence or defence), combat-related casualties, and military result (either victory or defeat). In this sense, the project is one of theory testing. As such, the aim has not been to 'reinvent the wheel' and construct an entirely new theory, but instead to see how well existing theories match the evidence gathered from disparate temporal and geographical locations.[50] In so doing we can arrive at a fair sense of which of these rival interpretations can be conclusively falsified, and perhaps more importantly, determine which enjoys a more compelling congruence with the data than its alternatives. There is, after all, much blood and treasure to be saved by pursuing the

[50] Stephen van Evera, *Guide to Methods for Students of Political Science*, (Ithaca: Cornell University Press, 1997), p89-95.

military strategy—whether it be of numerical preponderance, technological supremacy, or combat proficiency—that offers the greatest chance of success.

What follows is more than the usual matter of replication, however. Much of this theory testing treads on new empirical ground, a fact that leads us to consider why it is worth constructing a new dataset in the first place.

Methodologically, the chief criticism that can be leveled against political science's theories of war is the incompatibility of claiming to explain long-standing historical trends when the evidence cited in support is either insufficiently 'systematic', or fails to capture a concomitant breadth of human history. In terms of the latter concern, many studies sorely lack examination of cases extending beyond the modern era. For example, in the their statistical analysis of the power transitions argument, Organski and Kugler constrain their examination to "test periods" no earlier than 1860.[51] Kugler and Domke are even more constrained, matching their theory to empirical evidence no further back than the 1904-5 Russo-Japanese War.[52] Biddle's explicit consideration of the battlefield victory literature is focused on the 20th century.[53] This restriction represents a serious failing, for not only does it reduce sample size, it also deeply undercuts confidence in the applicability of the literature's insights across time. More specifically, while such work may tell an interesting story about the twentieth century, if we restrict ourselves to this period alone it is impossible to a get sense of how unique there period is. There can be no understanding of what the industrial revolution—and perhaps now IT revolution—have done to the shape and nature of war without a consideration of what were the

[51] A.F.K. Organski & Jacek Kugler, *The War Ledger*, (Chicago: University of Chicago Pres, 1981), p49.
[52] Jacek Kugler and William Domke, "Comparing the Strength of Nations," *Comparative Political Studies*, 19 (April 1986), p39-70. Doran looks back to the year 1500 AD, yet predicates his dynamics on mere "estimations" or stylized trajectories, rather than explicitly stated empirical metrics, for all years prior to 1815. Charles F. Doran, "Economics, Philosophy of History, and the 'Single Dynamic' of Power Cycle Theory: Expectations, Competition, and Statecraft," *International Political Science Review*, 24:13 (2003), p24.
[53] Biddle, *Military Power*.

circumstances that came before it. Rectifying this shortcoming will require moving beyond the established collection of cases and pushing further into the past. Only then will the evidence assembled match the breadth of these theoretical claims.

The second methodological concern is that even research that goes beyond the immediate past generally does so in a haphazard and unsystematic fashion. Gilpin's hegemonic transition argument serves as a case in point. While it pays close attention to the key historical developments and dynamics of the last two millennia,[54] the work is primarily a deductive model and accordingly makes no concerted effort to match its findings (that risers attack when disequilibrium is reached) with the empirical record. Gilpin's is a fine, logically interconnected theory. But it has not been verified empirically. Another illustration of this weakness comes from Copeland.[55] True, his *Origins of Major War* takes a decidedly more empirical focus. Yet even here breadth is obtained only by sacrificing rigour. Though conflicts as chronologically distant as the Punic Wars are included, the work provides no systematic treatment of power dynamics over time. Nor does it even provide a methodology of how best to track these trends. Case studies are chosen for their qualitative virtues, rather than a systematic quantification of the power dynamics behind these clashes. Copeland's approximations of power are based on historically-contingent, qualitative claims, and therefore lack the ability to prove the underlying hypothesis (that decliners attack) has remained consistent throughout the ages.

In many ways this failure of methodology is predicated on a lack of accessible data. The problem becomes particularly acute the further back in time one goes. The popular Correlates Of

[54] Robert Gilpin, *War and Change in World Politics*, (Cambridge: Cambridge University Press, 1981) does well to incorporate the pioneering works of the 1970s, including North and Robert Paul Thomas, *The Rise of the Western World*, (Cambridge: Cambridge University Press, 1973).
[55] Dale Copeland, *Origins of Major War*, (Ithaca: Cornell University Press, 2000).

War (COW) dataset, for example, extends back no further than 1815.[56] Even the—much harder to obtain—U.S. Army Concepts Analysis Agency's CDB90 dataset includes no battle older than the 17th century. Critically, this is not because historians have failed to uncover rough approximations of the basic quantitative facts surrounding history's major battles. Such surveys do, in fact, exist.[57] The problem is that their data has simply not been collected into a single, accessible database. This unfortunate shortcoming serves as the dissertations' second primary motivation. Indeed, the aim has been to systematically collect data on the numbers committed, casualties incurred, and the efficacy of strategic posture—whether victory goes to offensive or defensive action—for violent contests dating as far back as existing historical research allows. Thus not only does this project seek to collect the data necessary to facilitate new and better tests of existing theories, but by collating this data into a coherent, user-friendly form, the dissertation's dataset can be used to assist the later research efforts of not only the author but others as well.[58]

1.2 Methodological Approach

We move now to a consideration of the methodology necessary to fulfill the project's ambitions. Most crucial will be an explanation for why the battle was chosen as the major unit of analysis, along with careful consideration of how dependable is the historical data upon which this study relies.

[56] Available at http://www.correlatesofwar.org/.
[57] See, for example, T.B. Harbottle, *Dictionary of Battles*, (London: Swan Sonnenschein, 1904); G. Bodart, *Losses of Life in Modern Wars*, (Oxford: Clarendon Press, 1916); John Perrett, *The Battle Book*, (1996); Stephen Basey, David Nicolle, and Stephen Turnbull, *The Timechart of Military History*, (Herts: Worth Press, 1999); David Chandler (ed), *The Dictionary of Battles*, (New York: Henry Holt and Company, 1987).
[58] The dataset is available at http://web.me.com/sean_m_c/Site/Academic_Details.html.

Why Battles?

There are two longstanding traditions in the collection of quantitative historical military data. Some studies collect data on discrete engagements, or battles. Others collect on wars.[59] Before proceeding with our study, it is necessary to evaluate the decision to choose battles as the unit of analysis rather than the latter. In short, we must demonstrate that the chosen methodology will lead to valid inferences regarding the causes of military victory and defeat.

There are two chief reasons why battles were chosen. The first is methodological, for the historiography of battles enjoys a series of data that is much more precise and far more complete than that of wars. Obtaining reliable peak strength estimates for individual engagements is a much easier task than for a war's total mobilization figures, even for relatively recent struggles. It is much easier to postulate the size of an army in the field, battle lines drawn, than to surmise the number of all the citizens pledged to arms from across a far-flung polity. In the premodern era the distinction was particularly clear, as troop dispersion was generally concentrated enough to allow observers to watch the battle unfold before them. In antiquity, an army some 100,000 strong would have taken up just $1km^2$ of front space, placing even the most titanic struggles of the day well within viewing distance.[60] As late as the Napoleonic Wars, front space for a similarly-sized army had still only grown to about $20km^2$.[61] In contrast to this rather straightforward calculation, totaling troop numbers on all fronts and through a series of overlapping engagements is a much more onerous task.

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[59] Unfortunately, an even greater concern than the choice of one or another is that much of the existing literature does not distinguish between the two. The reader is thus left at a loss regarding what specific outcome—be it battle or war—the author is speaking of. Although they are not alone, Realists and their balance of power theories are especially bad at this. John Arquilla's *Dubious Battles*, for example, has 'battle' right in the title, and yet the pages within are focused on wars in their totality.

[60] This certainly would have been the case during preparatory prelude to fighting. It is true, however, that once battle began much of the fighting would often be obscured by dust.

[61] Trevor N. Dupuy, *Attrition: Forecasting Battles Casualties and Equipment Losses in Modern War*, (Falls Church: Nova Publications, 1995), p28.

There are other complicating factors as well. The longer the unit of analysis, the more likely desertions and losses from disease will complicate the accounting process. In fact, sickness is traditionally the most dangerous aspect of military operations.[62] Prior to 1900, soldiers had a far greater chance of falling victim to microscopic parasites than dying for king and country at the hands of a bullet or sword. Yet these losses are neither the consequence of contact with the enemy nor easy to track. The constant cycling of wounded in and out of an army's ranks that takes place as a war drags on makes it difficult to arrive at a useful snapshot of relative strength. Battles are therefore a much handier unit of analysis because it is much easier to simply count the number of participants on a specific day of battle. Moreover, this difference in the degree of methodological difficulty is reflected in the historical literature.[63] While total deployment and casualty figures for specific battles have long been tallied and compiled in comprehensive fashion, it is much more seldom to uncover similar figures for wars in their totality. If anything, battles are therefore useful for reasons of data availability alone.

The second reason is theoretical. Battles make a worthy unit of analysis because, as John Keegan suggests, military history is "in the last resort about battle."[64] Battles are central to military affairs because they lie at the heart of what military action seeks to achieve: the resolution of a clash of competing interests. As Knorr: observes, "military power is ultimately

[62] In the pre-modern period, "The proportion of disease deaths was almost always at least 3:1, even in the healthiest of climates." (Clodfelter, *Figures*, p6.) In the tropics, European armies could face rates of 20:1, or even 100:1, in terms of disease-related to combat deaths. In more concrete terms, US disease deaths per 1,000 men stood at 110 in the Mexican War, 65 in Civil War (figures for the North only), 26 for Spanish American War, and 19 for World War I. It was not until WWI that bullets claimed more lives than disease. There we see Britain, whose troops were well treated after its Crimean debacle, lost only 69,912 to noncombat causes—a number just 1/10 of that of deaths from enemy fire. (To be fair, this figure was the lowest of all the main combatants, but does indicate what the technology of the age could achieve.) By WWII, disease was simply no longer the great killer it once was. Even fighting in the malaria-rife Pacific islands and Indochina, disease-related losses were less than 1/10 of the toll exacted by combat.

[63] We discuss the specific works of this literature below.

[64] John Keegan, *The Face of Battle: A Study of Agincourt, Waterloo and the Somme*, (New York: Penguin Books, 1984), p18. Keegan goes on to explain his typology of different battles, from attrition, to envelopment, and so on (p20-21).

the power to destroy and kill, or to occupy and control, and hence to coerce."[65] In this light, battles can be seen as the heart of Lasswell's description of politics, for it is through battle that the questions of 'who gets what, when and how' are settled in the most basic and brutal way possible.[66] As Cicero lamented, "what can be done against force without force?"[67] The violent application of force is what removes an opponent's capacity to resist an alternative set of values. This is what Clausewitz meant by defining "absolute victory…in terms of the disarmament of the enemy."[68] Battles, he continued, are where violence is used "to compel our opponent to fulfill our will."[69] The great Prussian thinker elaborated further:

> "War is nothing but a duel on a larger scale. Countless duels go to make up war, but a picture of its as a whole can be formed by imaging a pair of wrestlers. Each tries through physical force to compel the other to do his will…Force…is thus the *means* of war; to impose our will on the enemy is its *object*."[70]

There is therefore good reason why Frederick the Great concluded that "War is decided only by battles, and it is not finished except by them."[71] Battle therefore sits at the heart of armed struggle, no matter how big or how small.[72]

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[65] Klaus Knorr, "The International Purposes of Military Power," in J. Garnet (ed), *Theories of Peace and Security*, (London: Macmillan, 1970), p50.
[66] Harold Lasswell, *Politics: Who Gets What, When, How?*, (Whittlesey House, NY, 1936).
[67] Letter 12.3, from Cicero to Cassius, [Rome, early in October, 44 BC.]. See Cicero, *Selected Letters*, (Oxford University Press, 2008).
[68] As noted by Raymond Aron, "Introduction," in Herman Kahn, *Thinking about the Unthinkable*, (New York: Avon Books, 1962), p14. Clausewitz did recognize that "victory consists not only in the occupation of the battlefield, but in the destruction of the enemy's physical and psychic forces, which is usually not attained until the enemy is pursued after a victorious battle." Clausewitz, *On War*, Howard and Paret (eds), p71. Nevertheless, control of territory was integral for Clausewitz's conception of war as the "mere continuation of policy by other means," [Clausewitz, *On War*, Anatol Rapoport (ed), p119] since the conquest of territory or the overthrow of a rival government was the primary motivation of such policy. [Raymond Aron, *Clausewitz: Philosopher of War*, (Englewood Cliffs, NJ: Prentice-Hall, 1985), p101.]
[69] Clausewitz, *On War*, (J.J. Graham, trans., and Anatol Rapoport, contrib.), (Penguin Classics, 1982), p101.
[70] Karl von Clausewitz, *On War*, in Phil Williams, Donald M. Goldstein, and Jay M. Shafritz, *Classic Readings and Contemporary Debates in International Relations*, (Belmont Ca: Thomson, 2006), p140.
[71] Thomas R. Phillips (ed), *Roots of Strategy: The 5 Greatest Military Classics of All Time*, Vol. 1, (Stackpole Books, 1985), p391.

Generals in the 20th century were of similar mind. Bernard Montgomery, a British general well versed in conventional battles, argued that "A war is won by victories in battle."[73] Even Mao Tse-Tung, a wily guerilla who fought a very different type of war than Monty, concurred with this basic conclusion. Although Mao stressed that revolutionary wars are more contests of political will than barenuckle military affairs, he nevertheless conceded that victory cannot ultimately be achieved without a "decisive battle between the two armies."[74] This is not to suggest that the enemy's willingness and desire to take the field and oppose a belligerent is unimportant. The easiest battles to win are in fact those where the opponent simply does not show up. America's evacuation of Vietnam—predicated on an evaporation of the American public's willingness to continue the fight—made the job of the NVA infinitely easier. But an unwillingness to do battle is neither a necessary nor sufficient condition for victory. Even if a defending army leaves the field, for an attacker to be successful they still must assert *their* physical dominance of the terrain.[75] No political order can be established otherwise. For the NVA, the fighting did not stop when the Americans went home. No matter what, victory cannot

[72] Besides, the "the intuition behind the materialist conception of military power draws little distinction between wars and operations—where preponderant material is thought to win wars, it is ostensibly winning battles." Stephen Biddle, *Military Power: Explaining Defeat and Victory in Modern War,* (Princeton: Princeton University Press, 2004), p21. As a matter of logic, preponderance theory applies to battles and wars in the same manner.

[73] Quoted in Alger, *Quest*, p99.

[74] Mao Tse-tung, *Selected Military Writings*, (Peking: Foreign Languages Press, 1966), p122. See also Stuart R. Schram, *The Political Thought of Mao Tse-tung*, (New York: Frederick A. Praeger, 1966). The importance of battles in the postwar era should not be diminished either. Contrary to popular conception, Vietnam was not about hit-and-run tactics, but of set piece engagements. Dupuy's artillery-induced casualty statistics demonstrate that it was largely a conventional war. Some 43% of US battle casualties were caused by artillery and mortar shell fragments in Vietnam, with the rate for the North Vietnamese likely being much higher. Trevor N. Dupuy, *Attrition: Forecasting Battle Casualties ad Equipment Losses in Modern War*, (Falls Church, VA: Nova Publications, 1995), p59. Even today, in the insurgency-type conflicts of Iraq and Afghanistan, the fear of the West is not that the Karzai government cannot endure road bombs and ambushes, but that absent NATO and US support, the central government's weak forces will be comprehensively defeated in the field.

[75] Just as Mao suggested above, there is a reason why successful guerrilla armies—from Cuba to China—always convert to conventional ones in the final stages of a guerilla conflict. It is only way to capture the state. One cannot hit and run their way into office. Even when a guerilla forces grinds away an opponent through guerrilla action, it must eventually enter into conventional battle if it is to hold the terrain after the stronger power goes home. Ironically, after the French army left Algeria in 1962, the FLN forces were organized and operated in a manner little different than the French, for that was what they needed to establish control over the territory. See Alistair Horne, *A Savage War of Peace: Algeria 1954-62*, (Viking, 1962).

be achieved if, when the last account has been settled, one does not maintain control of the battlefield. It thus makes sense to focus on battles because that is the final test of where wars are won or lost.[76]

Dataset Construction

Next is the matter of dataset construction.[77] As discussed above, a large-*n* collection of independent engagements ('battles') formed the cases for examination.[78] Of the available sources, Perrett (1996) was the most comprehensive (in terms of chronological breadth) and accessible (in terms of summarized deployment and casualty figures) resource available. It therefore provides the backbone of the empirical data that follows. Following the compilation of Perrett's work, data from Chandler (1997), Badsey (1999), and then Clodfelter (2009) were used

[76] This is not to deny Clausewitz's observation "The conqueror in a War is not always in a condition to subdue his adversary completely." Cited in Martel, *Foundations*, p96. Tactical success may not lead to overall strategic victory. As Kissinger put it, "A military victory always has two components, its physical reality and its psychological impact…it is the task of diplomacy to translate the latter into political terms." Quoted in Charles W. Freeman Jr., *The Diplomat's Dictionary*, (Washington, DC: National Defense University Press, 1996), p395. Even so, given that victory in battle is a necessary—if not in many cases sufficient—precursor to such translation, this project and its choice of battles as its unit of analysis is a good start, with this question of diplomatic translation being left for subsequent inquiries.

[77] A similar project to this one is Levy and Morgan, who relied on Wright (1965), Sorokin (1937), and Woods and Baltzly (1915) for their pre-1815 data. Levy and Morgan's methodology was much as it is here. "While these [data sources] are individually unreliable, together they provide mutual validity checks. Any war listed in two of these is included in our compilation. Cases involving single-source wars are resolved by reference to Dupuy and Dupuy (1977) and Langer (1948). These two references are also important sources for the identification of imperial wars, which are only sporadically included in our main sources. Further ambiguities are resolved with reference to standard historical sources such as the *New Cambridge Modern History* (1957), Mowat (1928), and Hill (1914)." Levy and Morgan, "Frequency and Intensity," p740; citing Woods and Baltzly, *Is War Diminishing?* (BiblioBazaar, 2009 [1915]); Quincy Wright, *A Study of War*, (Chicago: University of Chicago Press, 1942); W.L. Langer (ed), *An Encyclopedia of World History*, (Boston: Houghton Mifflin, 1948); David Jayne Hill, *A History of Diplomacy in the International Development of Europe*, 3 vols. (London: Longmans, Green, & Co., 1914); R.B. Mowat, *A History of European Diplomacy*, (London: Edward Arnold, 1928); R. Ernest Dupuy and Trevor N. Dupuy, *The Encyclopedia of Military History*, (New York: Harper & Row, 1977); and Pitrim Sorokin, *Social and Cultural Dynamics*, (Boston: Porter Sargent, 1970 [1957]); and the *New Cambridge Modern History*, (14 vols.), (Cambridge: Cambridge University Press, 1951).

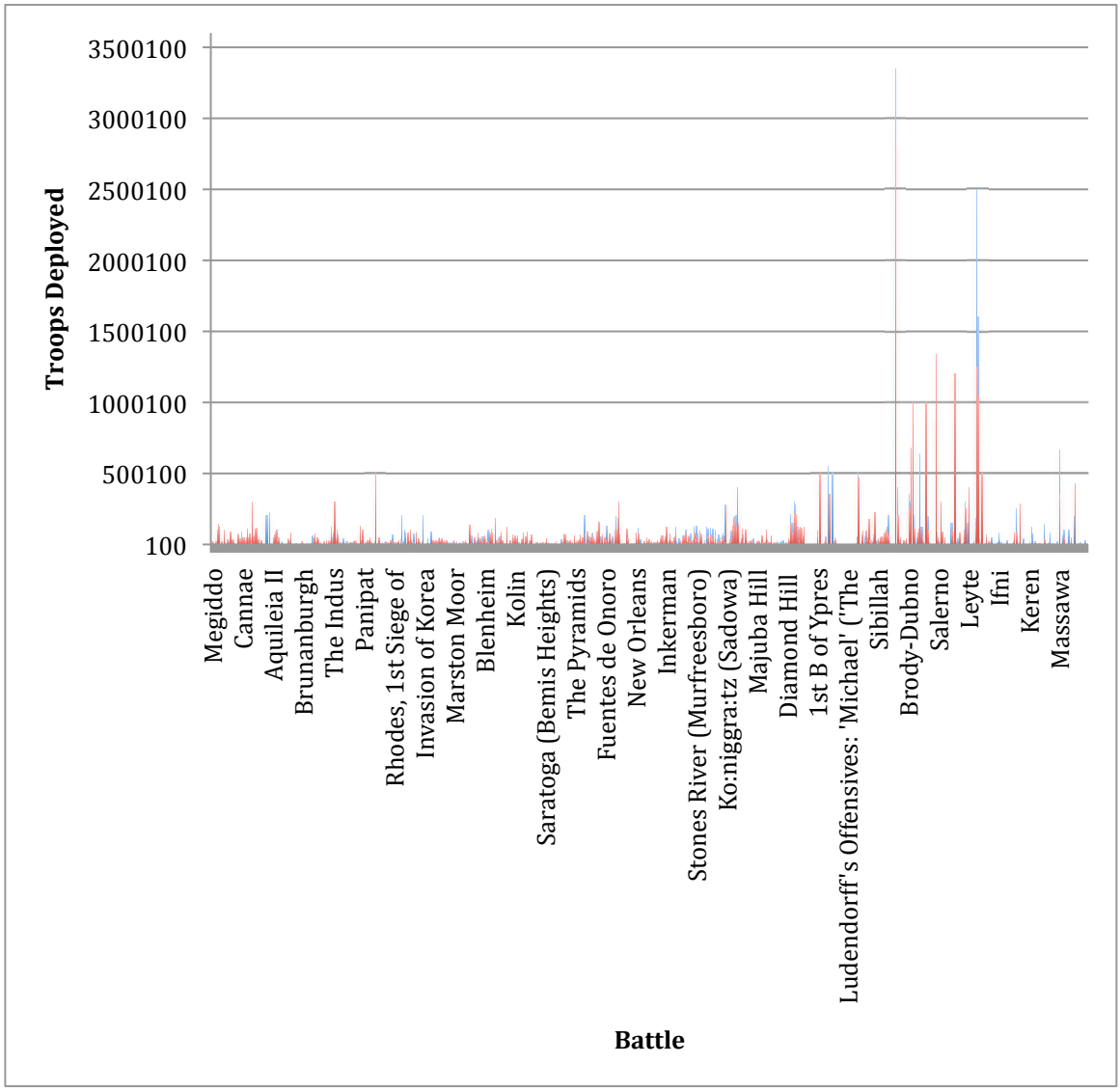
[78] It is important to recognize that this definition works well for both post-Agricultural Revolution and pre-Industrial Revolution fighting. In Agrarian times, belligerents would have just one or a few big battles and then go home, largely for reasons of material scarcity. Prior to this big battles were simply not possible. Instead, there was only steady—though decidedly murderous—attrition. Similarly problematic is that following the Industrial Revolution, or at least from Crimea (1853-55) onwards, battles have a tendency to bleed together. That being said, even the most well-supplied forces faces exhaustion at some point. One can therefore make the argument that distinct periods of contact and victory or withdrawal still delineate one battle from the next.

to add any missing battles and to reconcile gross discrepancies through cross-referencing.[79] Disagreements were resolved by adhering to the more common figure. This approach reflects the assumption that the dataset that follows should reflect the mainstream historiographical consensus. The exception, of course, are those instances where the available evidence appears to the author as patently erroneous. Finally, Eggenberger (2008) and Dupuy (1979) were used to clarify attacker and defender, as well as victor and loser, when the other sources left this unclear.

To be clear, the aim here was not a collection of history's most colossal or decisive engagements, such as those offered in the classic works of Crane, Creasy, and Fuller.[80] Instead, the aim was for a dataset much more comprehensive in scope. Indeed, this project has endeavoured to include the engagement size, casualty, and military posture details of as many battles as practical. This is because a fuller understanding of the dynamics behind victory requires a consideration not merely of the exceptional and historically significant, but also the mundane. A historically typical engagement may not loom large in storyteller's bards or Hollywood film, but when considered in totality, they have proven equally murderous. In all, a total of 754 battles were included in the final collection—though the amount of data available for each varies. This makes it, so far as the author is aware, the largest database of its kind. All the data is available at the author's personal website, web.me.com/sean_m_c/Site/Academic_Details.html.

[79] Perrett; Chandler; Badsey; Clodfelter; and Eggenberger. For full details see below.
[80] Edward Creasy, *Fifteen Decisive Battles of the World*, (London, R. Bentley,1851); Stephen Crane, *Great Battles of the World*, (J.B. Lippincott, 1900); and J.F.C. Fuller, *Decisive Battles of the Western World*, 2 vols. (HarperCollins, 1972).

Figure 1.1 Peak Battle Deployment, over time (belligerent A:B).



*Based on dataset total of 754 battles. Note: not to chronological scale.

The question, however, is to what degree can we trust this data, both in its original form and after it has been manipulated during collation? Regarding the latter question, the author has rechecked and crosschecked the historical numbers contained in the dataset. This is not to say the figures are certain to be free from transcription error and the like, but that concerted effort has been made to ensure they are as close an approximation to the truth as our current data and

techniques allow. Hopefully the reader can appreciate that, to the extent that this study errs, it is in good company.

How fine this company is, however, is a matter to consider further. There is no shortage of potential barriers to one's confidence in the reliability of historical statistics. Given that these figures are often dealing with events decades—if not hundreds of years—in the past, we must consider just how accurate these figures are likely to be. For that, we now move to a discussion of the historical techniques that lie behind the historical data used in this dissertation.

How Accurate Are Historical Statistics?

The two main forms of conflict-related statistics stretching back to ancient times are the size of armies involved in particular engagements and the number of casualties sustained as a result of their contests. These engagement and casualty figures are derived primarily from two broad sources: archeology and the literary record. As we shall see, neither offers sufficient reliability on its own. However, when used in concert with other historiographical techniques—particularly with the latter serving as a corrective for the former—the results can be quite impressive.[81]

Archeology is the business of unearthing the material remains of bygone eras. Generally, these specimens have been protected from the ravages of time only haphazardly. Not until the modern era has artifact endurance been the consequence of foresight and concerted preservation efforts.[82] Artifact survival has therefore generally been the result of a confluence of events fortunate for the archeologist—though usually not the original inhabitant! When cities crumble

[81] This section relies heavily on Philip Sabin, *Lost Battles: Reconstructing the Great Clashes of the Ancient World*, (Hambledon Continuum, 2009); and Jean Guilaine and Jean Zammit, *The Origins of War*, Melanie Hersey (trans), (Malden, MA: Blackwell Publishing, 2005).

[82] The author has witnessed a few exceptions. One was an Egyptian statue outside Karnak, where the Romans had previously cut up and buried the pieces in order to preserve it. This burying technique was also used by the Romans at the city of Troy, where they again sought to preserve some of the great achievements of societies ancient even to them.

or are abandoned, the remains are usually buried by shifting organic matter. Advancing greenery acts as a boon for later archeologists, for the accumulated material will protect whatever remains from the relentless harshness of the sun and rain.[83] Flash floods and volcanic eruptions similarly pour in layers of sediment, perhaps initially destroying a community, but thereafter preserving it for later recovery. Garbage and latrine pits offer another source of treasure, for that which was once discarded can be later used by archeologists to reconstruct societies long past. Such techniques are particularly useful because it is difficult for the subject to consciously bias the record in their favour. They offer a degree of personal impartiality, for while memoir writers and even independent observers have a tendency to record their thoughts with an eye to how they might appeal and influence future generations, one cannot easily remove all traces of a garrison's encampments, an army's metal equipment, nor even the detritus that so invariably follows human activities.[84] People do not usually dispose of rubbish with an eye to future biographers.

That being said, the archeological record is imperfect, for history is terribly haphazard in what it chooses to preserve. "Pitched battles in the open field are by their very nature evanescent phenomena, and leave little lasting archaeological record."[85] Even the temporary camps used by armies of thousands tend to vanish to the elements. What are generally left are graves and battle remnants, such as stone arrows or metal helmets. Unfortunately, such remains leave an imperfect record of what transpired. Even memorial structures that have stood the test of time, such as the Soros at Marathon or the Lion monument at Chaeronea, leave some degree of interpretation over the specifics of a particular contest. The same can be said for artifacts found

[83] The volcanic eruption at Vesuvius provides a case in point. While the toxic mix of poison gas and overpowering clouds of ash extinguishing the Roman city Pompeii and any souls remaining in it, the ash protected the remains and left us with one of the most important archeological finds in all of the Roman era. On Vesuvius, see Mary Beard, *The Fires of Vesuvius: Pompeii Lost and Found*, (Belknap Press, 2010).
[84] One needs neither many people nor for them to stay long before humans leave their (rubbish-filled) mark. The author's experience in nature park conservation, even in remote regions, attests to this.
[85] Sabin 2007, p3. Lengthy sieges, however, are more likely to leave archeological deposits.

on-site. Although these finds offer a wealth of information—from a sense of whose armies were deployed to the technological condition of the day—they tend to say little about tactical developments, much less specific compositions and deployments. Tombstones speak to the failure of tactics, not to what those tactics explicitly were. Field studies are thus useful, but only up to a point. The same can be said for off-site archeological finds, such as decorative or triumphal works of art. Pictures and sculptures uncovered in the public works or the houses of the rich do much to relay general knowledge about warriors and warfare in the era concerned, at least so "long as one is constantly aware of the potential for artistic distortions—such as the portrayal of hoplites fighting naked or with their helmets raised, or the unrealistic uniformity of the Roman soldiers on Trajan's column."[86] In short, while physical artifacts, found both at the place of contest and otherwise, offer an invaluable wealth of knowledge, they nonetheless leave much of the story untold.

To fill in the missing details we rely heavily on the literary accounts of contemporaries. These ancient writers usually even went so far as to provide explicit numbers regarding the great military clashes of their day, at least for one side, and sometimes two. Histories written by authors like Thucydides, Xenophon, Polybius, Livy, Plutarch, and Caesar all provide invaluable additions to our understanding of the past. They recorded—if not always first hand—eyewitness accounts of these struggles, preserving their tales for the present day. Who can read Livy's account of Cenosphale and remain unmoved by the violence?[87] Livy records, for example, the Macedonians' reaction to the ghastly devastation wrought by the Roman *gladius*. The observers were horrified "when they [saw] bodies chopped to pieces by the Spanish sword, arms torn

[86] Sabin, 2007, p3-4. Another example is how the Ammendola Sarcophagus at Rome's Capitoline Museum depicts Romans and Greeks fighting each other in a completely unrealistic manner. As Dyer observes, "'A slash-cut rarely kills,' the Roman army manual says, but it makes for great artistic drama." *War*, p29.
[87] Cited in Trevor Dupuy, *The Evolution of Weapons and War*, (Fairfax: Da Capo, 1990), p16-7.

away, shoulders and all, or heads separated from bodies, with the necks completely severed, or vitals laid open." Similarly remarkable is an account of the tactical advice given to Tuthmose III by his officers on the eve of Megiddo (1479 BC):

> "How can we take this pass which is so narrow? It is reported that the enemy are at the exit in great numbers. Will not the horses have to go single file; and the soldier likewise? Won't our vanguard already be fighting (at the far end of the pass) while the rear stands here at Aruna and does not fight?"[88]

This exchange describes well the angst the young king's commanders must have felt on the eve of battle. They had been told to strike boldly through the narrow Aruna pass, a plan which evidently filled them with trepidation. But as the inscriptions at Karnak tell us, the king rejected this advice and ordered his army forward, eventually routing the Canaanite coalition. Such detail offers remarkable insight into the events of the past. No archeological remain could capture the Egyptian fear as well as words do.

Unfortunately, written sources are not wholly dependable. As with the archeological record, written accounts can be arbitrary and unfair. Common is an emphasis on anecdotes rather than summary statistics, and an overall general vagueness of details. The latter often occurs because the author is describing events retold by others. In fact, sometimes accounts are written entire centuries after the fact. Even when contemporaries observe an event first-hand, the fog of war can obfuscate the true meaning of what they are witnessing. A front-row seat, after all, does not guarantee an understanding of backroom maneuvering. Unsurprisingly, these pathologies can lead to serious misunderstandings.[89] And of course, the ancient works lacked

[88] Cottrell, *Pharaohs*, p80.
[89] A particularly egregious example is Livy (XXXIII.8), when he misunderstands Polybius' account (XVIII.24) of the Macedonian phalanx leveling their pikes at Cynoscephalae, believing instead that they discarded their pikes completely, relying on their swords instead!

our modern scholarly standards. Even conscientious writers such as Thucydides rarely gave explicit citations.[90] There is good reason, therefore, to avoid assuming unalloyed veracity with the ancient accounts upon which we so heavily rely.

Fortunately for this dissertation, the field of historiography has considered these matters at length. Delbrück (1920) and Whatley (1964) in particular gave very clear answers to the question of when to accept ancient figures *holus bolus* and when to revise them in light of more modern evidence.[91] This work pioneered the historiographical methods needed to provide a platform from which to measure the worthiness of the ancient claims. Using the battle of Marathon as an example, Whatley argued that while imperfections in the historical record made it clear that there are very real limits to our ability to penetrate the veil that conceals the reality of ancient battle, there are a series of scholarly techniques that can improve our confidence in the ancient material.[92] Such methods include the personal inspection of battlefield geography,[93] the

[90] Sabin 2007, p4-6. To be fair, though, Thucydides' methods were incredibly sophisticated for the time, endeavouring as he did to double- and cross-check all sources. See Thucydides, *The Landmark Thucydides: A Comprehensive Guide to the Peloponnesian War*, (Ed. Robert Strassler; Trans. Richard Crawley), New York: Simon & Schuster, 1998.

[91] Hans Delbrück, *History of the Art of War*, Vol. I, 3rd ed, W. Renfroe (trans), (Lincoln: University of Nebraska Press, 1975 [1920]), p112-13, 212, 246, 325-7, 399-401, 459-76, 542-9. Delbrück treated the ancients with great skepticism, and used the logistical understanding of the day to sharpen the estimates provided, as well as results between victor and vanquished. Some have claimed, however, that he was a bit too overzealous in his evening of the tallies. In particular, while near-equality in numbers may have been the norm in Delbruck's age of mutual bloodbath (the wars of attrition of the 19th and early 20th centuries), the later 20thC demonstrated that smaller-yet-more-proficient armies can enjoy tremendously asymmetrical outcomes. Israel's wars against its neighbours provides a case in point. Thus today we are a little more willing to accept the great asymmetries offered by the ancient scholars, and hold Delbrück's inclination to revise downwards these ratios in check.

[92] N. Whatley, "On the possibility of reconstructing Marathon and other ancient battles," *Journal of Hellenic Studies*, 84 (1964), p119-39. This and a discussion of the literature that followed is recounted in Sabin, 2007, p6-10.

[93] See J. Kromayer, *Antike Schlachtfelder in Griechenland*, Vol. I. (Berlin: Weidmannsche Buchhandlung, 1903); Kromayer, *Antike Schlachtfelder in Griechenland*, Vol. II. (Berlin: Weidmannsche Buchhandlung, 1907); J. Kromayer and G. Veith, *Antike Schlachtfelder in Italien und Afrika*, Vols I and II, (Berlin: Weidmannsche Buchhandlung, 1912); Kromayer and Veith, *Schlachten-Atlas zur Antike Kriegsgeschichte*, (Leipzig: J. Wagner & E. Debes,1922-9); Kromayer and Veith *et al*, *Antike Schlachtfelder*, (Berlin: Weidmannsche Buchhandlung, 1924-31); W.K. Pritchett, *Studies in Ancient Greek Topography*, Part I. (Berkeley: University of California Press, 1965); Pritchett, *Studies in Ancient Greek Topography*, Part II. (Berkeley: University of California Press, 1969); N.G.L. Hammond, "The two battles of Chaeronea (338 BC and 86 BC), *Klio*, 31 (1938), p186-218; Hammond, "The campaign and the battle of Marathon," *Journal of Hellenic Studies*, 88 (1968), p13-57; Hammond, "The battle of Granicus River," *Journal of Hellenic Studies*, 100 (1980), p73-88; Hammond, "The battle of Pydna," *Journal of*

construction of physical models and use of battlefield re-enactments,[94] and even just utilizing 'common sense' to evaluate the plausibility of a historical claim.[95] Situating battle totals in the context of known political, economic, and biogeographical constraints is similarly useful. There are certain limits, for example, to how large the population of an agrarian society can grow, and how many soldiers then can mobilize. Together, these techniques can offset the weaknesses of the other. As Tuchman notes, corroborating detail "is the great corrective."[96] In short, the data must fit sufficiently well with other research so as to form a larger theoretical whole.[97] When it does, we can enjoy a manner of confidence in results. Battles statistics therefore need not be seen as grossly unreliable.[98]

Hellenic Studies, 104 (1984), p31-47; Hammond, "The campaign and the battle of Cynoscephalae in 197 BC," *Journal of Hellenic Studies*, 108 (1988), p60-82.

[94] See Whatley (1964), p126; and W. Donlan and J. Thompson, "The charge at Marathon: Herodotus 6.112," *Classical Journal*, 71 (1976), p339-41. Also P. Connolly, "The Roman fighting technique deduced from armour and weaponry," in V.A. Maxfield and M.J. Dobson (eds), *Roman Frontier Studies 1989*, (Exeter: University of Exeter Press, 1991), p358-63; Connolly, "Legion versus phalanx," *Military Illustrated*, 124 (1998), p36-41; M. Junkelman, *Die Legionen des Augustus*, (Mainz: Phillpp von Zabern, 1986), R. Gabriel and K. Metz, *From Sumer to Rome: The Military Capabilities of Ancient Armies*, (Westport: Greenwood, 1991); and A.T. Croom and W.B. Griffiths (eds), "Re-enactment as research," *Journal of Roman Military Equipment Studies*, 11 (2000). One should keep in mind, however, that it is both difficult to get the necessarily huge numbers of people and equipment together to complete a full-scale re-enactment, and that the participants do not actually want to kill each other, thereby somewhat dampening the accuracy of the re-creation. Because of this, a recent emphasis has been on tabletop or game modeling, which, though not conducted in the outdoors, still use human decisions makers bound by physical rules, and thus provides a sense of what was and was not possible on the day of actual battle. See Sabin, *Lost*.

[95] One of the great accomplishments of this technique is Delbrück's pointing out the absurdity of Herodotus' claim of Xerses' army being five million strong—for the rear of the column would only be leaving Sardis when the front reached Thermopylae. See Whatley (1964), p126.

[96] Barbara Tuchman, *Practicing History*, (New York: Knopf, 1981), p34.

[97] The author has spoken at greater length of this in Sean Clark, "Revealing Clio's Secrets: The Case for Macromeasurement," *The International Journal of Interdisciplinary Social Sciences*, (Volume 4, Issue 8: 2009), p101-114.

[98] This is true both for ancient as well as more recent engagements. Indeed, the two can be seen as enjoying a relatively equal level of reliability, even though this arrives from two very different challenges. The chief problem facing battles of even just a few hundred years ago is a scarcity of data. The longer back in history, the fewer artifacts—whether archeological or written—that remain. For more recent struggles, however, the problem is not so much an absence of data (although this can be a serious problem; students of the First World War, for example, face the sad fact that many crucial documents—such as the Schlieffen plan—were destroyed by aerial bombardment in the Second World War) but rather the tremendous complexity than accompanies modern war. The Russo-German battles of 1941-45, for example, raged over the scale of weeks and months and across hundreds of kilometers. Thus despite a *surfeit* of data, untangling each engagement is a painstaking affair. In many ways, it is easier to arrive at a relatively reliable estimate of the number of Greeks and Persians at Marathon (490 BC) than it is the Germans and French at Verdun (1916), constantly cycling in and out as troops and units were. Of the over 330 infantry battalions in the French army, for example, 259 of them went through Verdun, each for a varying length of time. Indeed, the

Table 1.1 A Sample Biogeographical Constraint (population density, by agriculture type).

Agriculture Type	Pop Density (Persons/km2)
Foraging	0.01-0.9
Pastoralism	0.8-2.7
Shifting agriculture	10.0-60
Traditional farming	100-950
Modern agriculture	800-2,000

*Source: I.G. Simmons, *Environmental History: A Concise Introduction*, (Oxford: Blackwell, 1993), p37.

The lesson of all of this is that "No work which deals with the activities of men of all nations and all parts of the world since the dawn of history can hope to be either completely accurate or totally comprehensive."[99] It is undeniable that "any attempt at quantitative modeling of ancient warfare is highly vulnerable to erroneous assumptions, and the spurious precision that specific numbers bring should never obscure the enormous variation and margins for error that need to be borne in mind."[100] Even the work by a historian so rigorous as Clodfelter (2009) can boast nothing more than tentative claims. He tells us that "But for all my efforts at cutting through the exaggeration, propaganda, and outright mendacity with which the statics of warfare are weighted, it must still be admitted that every quantity in the work may legitimately be questioned."[101] And question these we must. Yet so too need we remember the words of Richardson, writing more than a half-century ago: "Although the numerical estimates obtained in this way are generally of very poor quality by the standards of experimental physics, yet they are

only dependable aspect was that "there would be no relief until part of the unit had been destroyed. The only certainty was death—for one, or other, or all." Marc Ferro, *The Great War: 1914-1918*, (Boston: Routledge & Kegan Paul, 1984 [1973]), p77.

[99] Dupuy & Dupuy, *Encyclopedia*, pxiii.

[100] Sabin, *Lost*, pxiv-xv.

[101] Clodfelter, 2009, pxxi.

sufficiently definite for the purpose of analysis applied to totals over a century."[102] When dealing with the basic needs of probabilistic determination the standard is not perfection—nor even the caveated boasts of the physical sciences—but rather 'good enough.' When foundering on calamitous shoals, even the slightest assistance gives reason to cheer. Crucially, through the means described above we can arrive at data of the necessary quality.[103] Besides, "if we discount such information we might as well give up studying these battles altogether."[104]

Data Validity Problems

Data validity is the matter of an observer's confidence that they are measuring what they actually want to measure. In other words, does the sample accurately reflect the underlying population, or is there some sort of systemic bias that makes it inappropriate to draw inferences from the former and apply them to the latter? On this count the project's dataset faces two chief obstacles. Most pressing is the geographic distribution of cases, for there appears to be a severe European bias in the literature upon which the dataset of this dissertation rests. Indeed, while it is common for Western scholars to confidently discuss battles like Cannae, Agincourt, Austerlitz, and Stalingrad, details regarding Eastern examples are far less well known. All 15 battles of Creasey's *Decisive Battles of The World*, for example, took place in the West.[105] More recent evidence of this Euro-centrism can be found in the *International Library of Essays on Military History Series*, (34 vols). Of these, Europe gets 12 specific volumes, whereas China is

[102] Lewis F. Richardson, *Statistics of Deadly Quarrels*, (Pacific Grove, Calif.: Boxwood Press, 1960), p8.
[103] Moreover, social scientists should avoid becoming to envious of their physical science brethren in the first place. "Doubts in experimental physics are settled by the substantial agreement between many workers in different countries; yet their agreement is never perfect. See for example the successive determinations of the speed of light since Römer first found it in A.D. 1676. [Thus] Can it be otherwise in history?" Richardson, *Statistics*, p126. Richardson would know, for he was trained as a physicist.
[104] Sabin, *Lost*, p12.
[105] Edward Shepard Creasy, *Fifteen Decisive Battles of the World: From Marathon to Waterloo*, (London: R. Bentley, 1851). Joseph B. Mitchell's update and expansion of the work to 20 battles did nothing to improve its geographic scope. Edward Shepart Creasey and Joseph B. Mitchell, *Twenty Decisive Battles of the World*, (Konecky and Konekcy, 2004). Later editions of Creasey's worked simply inserted 'Western' into the title.

subject to just one. Nor does this massive discrepancy of scholarly attention include the fact that Europe garners the lion's share of the attention of the other, epoch-specific volumes in addition. Meanwhile, even North American scholars are dreadfully ignorant of non-European battles that have taken place in their own back yard. Scholars such as the Dupuys, Ferrill, and Kagan speak much about *European* ancient warfare, but not that of the New World.[106]

The consequence is that while we cannot be conclusive until the full population of events has been classified, there is eminent reason to suggest the dataset skews heavily towards European experience. This failing is not necessarily for reasons of purposeful omission, but rather the consequence of a lack of familiarity with languages and history outside the Western tradition. It will therefore take a concerted effort by historians to incorporate the full body of extra-European battle into mainstream historiography. Until then, the conclusions reached in this dissertation must be caveated with an understanding that the conclusions drawn may prove more applicable to the Western world than elsewhere. Although it may be possible that these forces studied below operate irrespective of geographic location, this cannot be conclusively determined until presented with the necessary evidence.

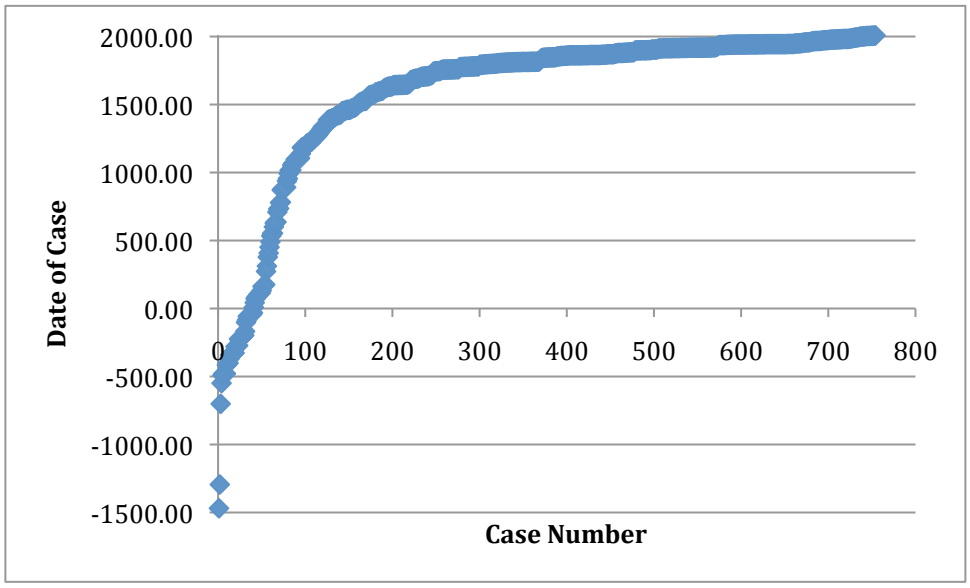
Related is the matter of the dataset incorporating only those battles recorded in the historical record. Some, such as Eckhardt, have assumed that if ancient sources did not record an event, it is either unworthy of note or simply did not exist.[107] This, however, is an egregious error to make. As we have seen, written records can be destroyed and the physical traces of battle worn away. It is consequently likely that many great and terrible contests have been completely lost to the ravages of time. A cavalier attitude toward the vagaries of history ignores

[106] Midlarsky, *Handbook of War Studies*, p62.
[107] "Since records have been kept since about 3000 B.C., and since historians have always been careful to record such events, I assume that no record of these events in historical times means that they either did not occur, or, if they did, were insignificant." William Eckhardt, *Civilizations, Empires and Wars: A Quantitative History of War*, (Jefferson, NC, 1992), p183-4.

this, thereby undercutting the universality of the inferences made. More specifically, it does no good to rely on the historical record—both archeological and written—when considering the prospects of pre-agrarian violence. Indeed, battles conducted between tribal societies face an almost infinitesimally small chance of surviving until the contemporary era. Absent writing and corrosion-resistant materials such as metal, most traces of these struggles will have long since evaporated. But one should not, however, assume that primitive societies were invariably pacific. In contrast, what little evidence that remains suggests the complete opposite.[108] Yet these struggles cannot be understood by the methodology advanced here. This dissertation will therefore offer no insight regarding to course and conduct of organized violence in primitive societies. The validity of the inferences below apply only to societies having undergone the agricultural revolution.

[108] As work by Keeley and Otterbein have made clear, the assumption of pre-agrarian tranquility is completely without substantiation. See Lawrence H. Keeley, *War Before Civilization: The Myth of the Peaceful Savage*, (New York: Oxford University Press, 1996); and Keith F. Otterbein, *How War Began*, (College Station: Texas A&M University Press, 2004). See also Jean Guilaine & Jean Zammit, *The Origins of War*, Melanie Hersey (trans), (Malden, MA: Blackwell Publishing, 2005).

Figure 1.2 Distribution of Cases, (over time).



*Based on dataset total of 754 battles.

Conclusion

This heart of this chapter is a consideration of what level of uncertainty is acceptable for our purposes. It is undeniable that this dissertation is predicated on upon data that is sure to contain errors—some if it substantially so. Despite the methodological safeguards and 'correctives' outlined above, it is simply impossible to expect the contrary. This leaves us with the need to consider just if and when the inevitable errors that arise fatally sink the ambitions of telling a causal story across many centuries.

There is, of course, no certain way to answer this question. Those in the natural sciences will undoubtedly recoil at the margin of error that this study deals with. Their natural inclination will be to disregard the findings without second thought. A more balanced test, however, is to ask whether or not the story fits within a broader, plausible narrative. The Siege of Troy offers an excellent example of how this can be done. In isolation, the written account seems rather

dubious. The most famous aspects of Homer's depiction of the city's fall are a gigantic wooden horse, the clever trickery of the Greek invaders, and the shameful idiocy of the Trojan defenders. It is quite doubtful, however, that such a ruse was ever employed, let alone offered any hope of success. A wealthy city in a dangerous neighbourhood rarely plays the fool.

We can, however, discard the more fabulous elements of the account with a consideration of the other evidence on offer. Most obvious is that fortress walls generally do not fall down by themselves; they are instead usually battered to the ground. As such, it is likely that the story of the Trojan Horse is simply a "garbled account of the siege machinery with which the city's walls were finally breached."[109] Such a wooden structure, "several stories high, mounted on wheels, with a hide-covered roof to protect the men inside and a metal-tipped battering ram slung in the interior—the Achaeans [archaic Greeks] might well have dubbed it a wooden horse, leaving subsequent generations to embellish the story." Indeed, a siege tower pictured in an Assyrian bas-relief from roughly the same time looks remarkably like a giant horse.[110] Further evidence reinforces this hypothesis. Although the semibarbaric Achaean Greeks would not have had the technology to create such an engine themselves, they certainly could have hired military engineers from the more advanced of the Levant. As it was, the Greek siege coincided with the crumbling of the once-mighty Hittite empire, leaving "a lot of unemployed professional soldiers on the loose in Asia Minor." Lastly, archeological evidence from the Troy site itself "show evidence of huge fires and destruction among the great stone buildings and the refugee hovels packed tightly between them." Thus from fable, with a little hard work and a lot of corroborating evidence, we can arrive at a pretty good sense of what actually happened. And it is with this spirit of confidence that this project proceeds.

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[109] Dyer, *War*, p31.
[110] See *The Campaigns of Tiglath-Pileser III, from the Bronze Gates of Balawat, lower band* at the British Museum. A picture can be found in Dyer, *War*, p53.

1.3 Dissertation Plan

The last task of this introduction is to chart the specific course of the work that follows. As mentioned above, there are three main theories of battle victory. Each will be considered in detail, then confronted with the empirical evidence assembled as part of this new dataset. The central question for each chapter is how well the various hypotheses predict battle outcomes throughout history. In this the standard for outright theory falsification will be roughly the same results achieved by a coin toss. In other words, if a theory successfully predicts battle outcomes roughly 50% of the time, it is fair to say Machiavelli's Prince will have little use for it. With results like that it would be better to flip than leave fate to the hands of scholars and generals. Meanwhile, as returns improve, so too should our confidence that the hypothesized causal relationship between strategy and victory holds true.[111] The expectation should not, of course, be an ability to predict outcomes perfectly; the complexities of combat are far too volatile for that. But the dissertation's methodology does allow for a straightforward comparison of the predicative efficacy of each body of theory. The further standard these theories are held to is therefore not absolute, but rather how well they perform relative to each other. The more superior a theory is to its alternatives, the more desirable a policy prescription it becomes.

Chapter two addresses political science's most popular theory, numerical preponderance. Here the argument is that, as Napoleon suggested, "God is on the side of the big battalions." States with larger populations, larger or more sophisticated economies, larger militaries, or higher levels of military expenditure are more likely to win the wars they fight. Economic and

[111] The reverse is true as well. If a particular strategy were to result in victory just 20% of the time, for example, it would be reasonable to infer that the strategy is causally related to *defeat*, and therefore should be avoided by armies seeking anything other than glory at all costs.

military power is viewed as fungible, for the chief premise of this school is that economic strength is the fundamental underpinning of military might. Thus authors such as Wayman *et al* (1983) contend that victory depends more on industrial capacity than military preparedness. The ramifications of this assumption are hardly trivial. In fact, here lies "the heart of hegemonic transition theory and the debate over relative gains stemming from international cooperation, and [defines] much of the realist/mercantilist position in international political economy."[112] In a practical sense, economic decline leads to military weakness, while growth entails victory on the battlefield.

To test this theory we must look for an association between material preponderance and victory. To account for the slightly different variations of preponderance theory, chapter two examines both the troop strength and economic size of the belligerents involved. In terms of the former, estimates of troop numbers in battle are relatively abundant. Economic measures, however, are much more scarce. As a consequence, population data (which is relatively plentiful) is used as a proxy for wealth at least until the industrial revolution. At that point—roughly around 1800—it becomes both methodologically necessary (for national differences in the productivity of this labour suddenly became important) and empirically possible (for in this period national production estimates now exist) to shift to the more accurate GDP data. Unfortunately for the theory, none of preponderance's three hypotheses fares well when confronted with such evidence.

Chapter three looks at the field's next most popular argument: that which deals with technology's effect on military capability, or what is known as the 'offence-defence balance.' By this it is meant the assumption that there is a military-technology equilibrium where it is

[112] Stephen Biddle, *Military Power: Explaining Victory and Defeat in Modern Battle*, (Princeton: Princeton University Press, 2004), p14.

either "easier" to conquer territory or to defend it.[113] The basic prediction is that international events will reflect whether offence or defence dominates (a measurement that must not only include the design of weapons systems, but also the training and organization of the military forces that use them). This condition is said to provide the most benefit to large and offensively oriented forces, such as powers with large standing armies or stocks of offensive weapons. When offence dominates "the security dilemma becomes more severe, arms races become more intense, and war becomes more likely."[114] An exemplar of such a crisis is the First World War.[115] On the other hand, when defensive weapons and strategies are dominant, conditions are much more stable and conflict is easier to manage without resort to arms. In this regard, the theory is optimistic; when defence has the edge, stability is likely to prevail.

The best way to test this hypothesis is to compare strategic posture—whether offensive or defensive in nature—against battlefield outcomes. If victory repeatedly accrues to a particular posture in a given epoch, it can be safely inferred that existing conditions are in some way systemically biased towards that particular orientation. While this conclusion cannot make certain that technology is the ultimate cause of that orientation's success, such a relationship is a necessary prerequisite if technology theory is to hold true. Technology cannot be seen as a primary causal force if the returns to strategic posture vary widely. Yet when we look for such consistency, none can be found. Nowhere in the evidence is there any suggestion of a consistent favouring of one posture or another, nor even an overwhelming advantage that accrues to the army with more capable technology.

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[113] Robert Jervis, "Cooperation under the Security Dilemma," *World Politics*, (January, 1978).
[114] Charles Glaser and Chaim Kaufman, "What is the offense-defense balance and can we measure it?," *International Security*, (Spring 1998).
[115] Stephen van Evera, *Causes of War*, (Ithaca: Cornell University Press, 1999).

Chapter four looks at the final theory, combat proficiency. Here the concern is less on material factors, and more the confluence of tactics, training, motivation, and effective deployment of field forces. Superior combat performance is seen as the hallmark of victory because technology can be confounded and superior numbers outmaneuvered. Frederick the Great, for example, would frequently defeat enemies nearly twice his size, while the strategic debacle at Bagration (1944) belied Germany's technological superiority over the Soviets. Such adeptness is most straightforwardly measured by relative loss ratios: the more casualties inflicted on an opponent per each loss incurred in turn, the more proficient the belligerent. While this is an admittedly *post facto* measurement—the final distribution of casualties is only known *after* battle is completed—loss ratios are nevertheless the clearest expression of an army's fighting ability. Indeed, military capability is ultimately a matter of being able to inflict more casualties upon the enemy than one endures in return. Blunderers may win battles, but they cannot be expected to outperform, in a casualty sense, the nimble. Moreover, loss ratios permit a systematic evaluation of the relationship between superior combat performance and victory over long periods of time, leaving them the metric best suited to our task here.

To this end, chapter four examines the relationship between relative combat performance and victory. Interestingly, the results suggest that skill is a powerful predictor of military success. The caveat, however, is that discrepancies in combat effectiveness can be overcome with sheer numbers, at least when the qualitatively inferior belligerent is roughly three times larger. As the battle of Wanat (2008) has recently demonstrated, even the most capable of armies must be wary that proficiency is no panacea. Moreover, the evidence also shows that it is possible to outwork and outmaneuver an enemy and yet still suffer defeat in the face of superior numbers. Exhaustion can cripple even the most talented army. The Finns, for example,

dramatically outfought the Soviets along the Mannerheim Line (1939), yet in the end had to sue for peace. In line with a dynamic that has been labeled here as 'proficiency erosion,' even the most gifted can survive preponderance only for so long. What follows in chapter five, then, is a brief consideration of what the implications of this crucial caveat are. While so doing, we adhere to Clausewitz's encouragement that "it is to no purpose, it is even against one's better interest, to turn away from the consideration of the affair because the horror of its elements excites repugnance."[116]

[116] Cited in Dave Grossman, *On Killing*, (Back Bay Books, 2009), pxxxiii.

Chapter 2: Testing Preponderance Theory

Wearing Away the Stone

Assessing Theories of Combat Attrition

"We are practically through the enemy's defences, the enemy has only flesh and blood against us."[117] British Field Marshal **Douglas Haig**, (October 1917)

Abstract

The most common political science explanation for military victory and defeat is numerical preponderance. This is the causal assumption that victory goes to the 'big battalions.' When it comes to battle, more is better, whether it be of the immediate concern of troops in the field, or a matter of the potential power of economic resources behind the front line. Unfortunately, this theory has rarely been tested, particularly against a series of cases with great historical breadth. This chapter has therefore collected data from 750 battles, spanning nearly 3,500 years, and contrasted these empirical details against the core hypotheses of preponderance theory. Unfortunately for the theory, the returns to preponderance are highly ambiguous. When examined through the vast sweep of history, armies both large and small emerge victorious in nearly equal fashion—a result highly contrary to the theory's central claim.

[117] Cited from John Keegan, *The First World War*, (Vintage Canada, 2000), p367.

Mass has generally been considered by war's leading theoreticians as a "class above" other principles, such as surprise and economy of force.[118] Generals in particular tend to view the deployment of decisive numbers at decisive points as the most crucial precursor to victory. This certainly was the case in the Great War, where Haig and his contemporaries viewed a preponderance of force, directed against crucial salients—such as Ypres, the Somme, and the Aisne—as the key to unlock the Western front stalemate that threatened to bleed their armies to death. In classic attritional terms, the French staff, concluded that "breakthrough followed by exploitation is impossible until the enemy has been so worn down that he has no reserves available to close the gap."[119] Yet tragically, the concentration of ever-greater numbers of men and materiel would not lead to victory. No matter how optimistic the assessment—such as Haig's callous and stunningly erroneous assertion in the epigram—an endless stream of fruitless casualties and perpetual stalemate laid the futility of this strategy bare. By the time Haig's words were written, roughly 70,000 British troops had been killed in the mud of Passchendaele (1917) and over 170,000 wounded, all to little change in the front lines. That the battle was preceded by a 19-day bombardment, sustained by 321 train loads of a shells—a year's worth of production for 55,000 workers—did nothing but help turn the battle area into swamp. In all, five months of bloody effort resulted in a gain of just 45 square miles—or roughly 8,222 men lost per square mile.[120] To the south, Nivelle's similarly misguided efforts along the Aisne resulted in 130,000 French casualties in less than a week. Thus rather than victory, these dreadful tallies stand as a testament to the futility of pursuing victory through preponderance. Judging by their performance in the Great War, generals, it seems, have a misguided faith in numbers. What

[118] John Alger, *The Quest for Victory*, (Westport, CN: Greenwood Press, 1982), p189.
[119] Cited in Theodore Ropp, *War in the Modern World*, (New York: Collier Books, 1973 [1962]), p248.
[120] Ropp, *Modern*, p250.

follows is a systematic examination of 3,500-years of battle data to determine if the years 1914-18 were a historical anomaly, or if this error has been consistent over time.

2.1 Literature Review: Preponderance Theory

Political science's most popular set of explanations for military victory and defeat are those related to *numerical preponderance*. Here the argument is that material superiority leads to victory, or that "states with larger populations, larger or more industrialized economies, larger militaries, or greater military expenditures should prevail in battle."[121] At the conceptual level, preponderance theory is straightforward. It is the view that, as Napoleon famously suggested, "God is on the side of the big battalions."[122] Put more formally, the argument is that the probability of military success correlates highly with the material strength of one nation or a coalition of nations relative to that of the adversary.[123] The balance of material resources is therefore crucial, for the probability of achieving military success is more a function of this capability distribution than any other concern.[124] Even the 'soft' version of preponderance theory holds that "when moral qualities, discipline, training, and armament are approximately

[121] Stephen Biddle, *Military Power: Explaining Victory and Defeat in Modern Battle*, (Princeton: Princeton University Press, 2004), p14.
[122] Such faith in numerical preponderance has long been part of folk wisdom. For Napoleon's quote, see John Bartlett, *Familiar Quotations*, 10th ed, (Boston: Little, Brown, 1919), no. 9707.
[123] See, for example, Bruce Bueno de Mesquita, in his *The War Trap*, (New Haven: Yale University Press, 1981).
[124] See the discussion in James E. Dougherty and Robert L. Pfaltzgraff, *Contending Theories of International Relations: A Comprehensive Survey*, (Longman, 2000), chapter 4, which touches upon the works of Kenneth Waltz, Karl Deutsch, and J. David Singer. See also J. David Singer *et al*, "Capability Distribution, Uncertainty, and Major Power War, 1820-1965,' in J. David Singer & Associates (eds), *Explaining War*, (Beverly Hills, Calif: Sage, 1979). Preponderance theory does not, however, suggest that the distribution of power is the sole determinant of the outbreak of war. Instead, decision makers on either side have to assess not only prospects for victory, but also values attached to those likelihoods. In this manner, the utility of war can vary from states to state—some leaders are incautious while others are risk averse. The same percent chance of victory may thus be tolerable to the former but not the latter.

equal, superiority of numbers is likely to prove victorious even against superior leadership."[125] More stridently, the 'hard' version argues that side that commands more of these power resources will "always win,"[126] regardless of other considerations.

This faith in the causal importance of material superiority is what unites preponderance theorists. Material goods are seen as the chief ingredient of military power. What actually constitutes these 'power resources,' however, is a matter of some dispute.[127] In simplified terms, there is a split between approaches that are concerned with labour and those with capital. Some in the literature echo Napoleon and stress the number of troops in battle as the ultimate expression of power. Armies with more troops than their adversary are thus seen as more likely to win. Others, however, find that troop numbers do not do justice to the virtues of material advantage. Superior wealth can, after all, be used to lavish an army with capital-intensive weaponry, improving combat performance in turn and thus making the prospect of victory more likely. The capital school therefore looks instead to the balance of aggregate economic potential between two belligerents when determining the probable victor.

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[125] W.D. Bird, *The Direction of War: A Study of Strategy*, (Cambridge: Cambridge University Press, 1920), p28. Bird ascribes even greater importance to preponderance with his further observation that "in war the result of the first great battle is largely influenced by the number of efficient units that are available," a fact which matters because "defeat in the first serious encounter is…often followed by failure in the campaign." (p33). Thus not only is victory in battle seen here as determined by who has the most front-line quality forces as the start of the war, so too is the entire struggle.

[126] Paul Kennedy, "The First World War and the International System," in *Military Strategy and the Origins of the First World War*, Steven Miller (ed), (Princeton: Princeton University Press, 1985), p38. Kennedy later refined this his theory, arguing that victory is "caused" by material superiority." Paul Kennedy, *The Rise and Fall of the Great Powers: Economic Change and Military Conflict from 1500 to 2000*, (New York: Random House, 1987).

[127] To be fair, the definition of power is an issue that has long perplexed much of political science. While "arguably the single most important organizing concept in social and political theory," [T. Ball, "New Faces of Power," in T.E. Wartenberg (ed), *Rethinking Power*, (Albany: State University of New York press, 1992), p14)] there is often little agreement in political science over what precisely power entails; and even less on how to measure it—so much disagreement, in fact, that Gilpin suggests that the "number and variety of definitions (of power) should be an embarrassment to political scientists." Robert Gilpin, *U.S. Power and the Multinational Corporation: The Political Economy of Foreign Direct Investment*, (New York: Basic Books, 1975), p24. In this light, preponderance theorists can be seen as different in degree, rather than in kind.

Economic Preponderance

Today, the most common variant is concerned with economic preponderance. The metrics offered here are less concerned with troop numbers or divisional strengths, but rather with relative economic size and industrial composition. The argument is that capital-intensive armies rely on factories and investment, and thus the success of military operations ultimately depends upon a state's ability to marshal overwhelming economic power. In this way, "all warlike operations depend so much on the condition of the national revenue."[128] Without the money to pay for them, there can be no swords or guns. As such, authors such as Singer *et al* (1972) argue military, industrial, and demographic capacities are the critical variables behind overall national capabilities.[129] This was certainly the view of Organski, who offered gross national product, or national income, as the best shorthand yardstick of national capability,[130] given that it serves as a reliable, quantifiable summary of population size and economic development.[131] For similar reasons, Waltz (1979) advocates the adoption of gross national product (GNP) as a rule-of-thumb measure of national power.[132] When armed with such measures, predictions regarding the outcomes of military contests become possible. More precisely, since economic strength is seen to translate to military strength, the balance of power

[128] See Edward Mead Earle, "Adam Smith, Alexander Hamilton, Friedrich List: The Economic Foundations of Military Power," in *Makers of Modern Strategy, from Machiavelli to the Nuclear Age*, Peter Paret (ed), (Princeton: Princeton University Press, 1986), p143; and William C. Martel, *Victory in War: Foundations of Modern Military Policy*, (Cambridge: Cambridge University Press, 2007), p39, 318 fn #150.
[129] J. David Singer, Stuart Bremer, and John Stuckey, "Capability Distribution, Uncertainty, and Major Power War, 1820-1965," in *Peace, War, and Numbers*, ed. Bruce Russett (Beverly Hills: Sage Publications, 1972), p21-27.
[130] A. F. K. Organski, *World Politics*, 2nd ed, (New York: Knopf, 1968), p358.
[131] Organski, *World Politics*, chpt 8, especially p203-210, in 1958 ed. See also Organski and Kugler *War Ledger*, p33-38.
[132] Kenneth Waltz, *Theory of International Politics*, (Reading: Addison-Wesley, 1979), p172. Like Organski, he elsewhere suggested that it is possible to rank the capabilities of states by reference to "how they score on *all* of the following items: size of population and territory, resource endowment, economic capability, military strength, political stability and competence." (p131). Even so, GNP was once again offered as a more parsimonious metric. See also Klaus Knorr, *The Power of Nations: The Political Economy of International Relations*, (New York: Basic Books, 1975), p45-69. To be fair, though, these authors did not deny other sources of power as well. See Waltz, *Theory*, p131; Knorr, *Power*, p69-78; Hans Morgenthau, *Politics Among Nations*, 6th ed, (New York: McGraw Hill, 1985), p80-108.

between rivals ultimately rests upon the international distribution of wealth.[133] The prospects for victory and defeat therefore rely on a comparison of each nation's stock of aggregate wealth.[134] According to economic preponderance theory, the winners of combat will be those who outmatch their opponents in this regard.

It is this 'outmatching' that is so important to economic preponderance theorists. Indeed, their argument is that wealth bestows combat power through its provision of capital-intensive weaponry. Wealthy nations need not rely solely on light infantry, but can instead afford to lavish their armies with high-cost tools of lethality. Examples include expensive equipment like siege works, cavalry, artillery, and, most recently, armour and airpower. In effect, material preponderance provides the firepower necessary to speed up the rate at which casualties are imposed on an enemy. Take how the theory looks to America's dominant 20thC economic position as the ultimate reason underlying the country's adoption of a capital-intensive means of fighting wars.[135] An abundance of wealth has given the United States far better opportunity than its rivals to spend mightily on vehicles, tanks, and bombs, all of which have served to increase the rate of losses inflicted on America's enemies. The North Vietnamese in the Vietnam War, for example, suffered dearly from relentless—and comparatively unchallenged—US airstrikes, which where the bequest of America's unmatched industrial might. So once again, more is

[133] Robert Gilpin, *War and Change in World Politics*, (New York: Cambridge University Press, 1981), p67.
[134] Note here the emphasis on *aggregate* wealth, as opposed to per capita wealth. While per capita figures offer a rough reflection of a country's relative standard of living, preponderance theory is ultimately concerned with its total stock of wealth instead. This is because societies that are populous but poor can still shift surplus to frontline forces, thereby belying their citizen's penury, and because those that are small and affluent still face relatively constrained treasuries. North Korea's 25 million citizens, for example, may be extraordinarily poor, but the draconian redistribution of surplus enables the deployment of an impressive array of tanks, artillery, and even nuclear weapons. In contrast, Luxembourg's 500,000-strong populace enjoys unsurpassed per capita wealth, yet still lacks the aggregate resources to match North Korea's arsenal.
[135] For works on US military history, see Russell Frank Weigley, *The American Way of War: A History of United States Military Strategy and Policy*, (1977); Robert Doughty *et al*, *American Military History and the Evolution of Western Warfare*, (1996); and Fred Anderson (ed), *The Oxford Companion to American Military History*, (2000).

better. Against such firepower poorer, less well-equipped forces will be ground to dust long before the preponderant side reaches the same state of desperation.

Troop Preponderance

This is not to say that the troop strength argument, the older of the two variants, is without its adherents either. Hans Delbrück, for example, has argued that victory in the Renaissance depended on the number of troops committed to battle: "only a large number of soldiers gave the prospect of victory."[136] Generals, too, often espouse the logic of numbers as chief arbiter of victory and defeat. Henry Wager Halleck, who rose to become Grant's chief of staff in the US Civil War, concluded that strategy—and thus victory—was a matter of the "art of directing masses on decisive points."[137] For Halleck, numbers were the central concern. Even Clausewitz infused some of his writing with preponderance notions. In a classic encapsulation of the logic of numbers, Clausewitz argued that "victory comes to the one who holds out a moment longer than the other."[138] Meanwhile Jomini, Clausewitz's contemporary and another veteran of the Napoleonic wars, went even further. His search for the "fundamental principle" underlying victory in war was in many ways built around the need to successfully "maneuver to engage the mass of forces against fractions of the hostile enemy army."[139]

To this commanders in the 20th century largely agreed. Echoing Napoleon, Erich Ludendorff held that "It is a fact that victory 'goes to the big battalions.'"[140] His French rival, Ferdinand Foch, concurred, lamenting that while "'Small battalions' have also carried off

[136] Hans Delbrück, *History of the Art of War within the Framework of Political History*, vol IV: *The Modern Era*, Walter J. Renfroe Jr. (trans), (Westport, CT: Greenwood, 1975-85), p63. Here he was writing about the "Organization of Mercenary Armies."
[137] Henry Wager Halleck, *Elements of Military Art and Science*, (New York: D. Appleton, 1862), p37.
[138] Cited in Martel, *Foundations*, p34.
[139] Antoine-Henri Jomini, *Précis de l'art de la guerre*, 2 vols., (Paris: Tanera, 1855 [1838]), I, p158. Cited in John Alger, *The Quest for Victory*, (Westport, CN: Greenwood Press, 1982), p26.
[140] Erich Ludendorff, *The Nation at War*, A.S. Rapoport (trans), (London: Hutchinson, 1936), p87.

victories," the Great War would have been conducted far more differently if France were materially preponderant. "Eight more Army Corps at the beginning of the War," he suggested, "would have secured us the victory."[141] Even the commander of the British Expeditionary Force, Douglas Haig, argued that there was no alternative to attrition. "In the stage of wearing-out struggle losses will necessarily be heavy on both sides, for in it the price of victory is paid."[142]

Haig's comment succinctly illustrates troop preponderance theory's brutal conception of battle. Armed contests are ultimately a matter of killing and dying. Indeed, the job of armies is to use deadly force to assert their command over a particular terrain. When a rival contests this imposition of will, violence ensues. The struggle will continue until one side is broken and can fight no more. This is why force strength and battle losses are so important. On one hand, the more troops a belligerent deploys, the more there are to do the killing. More troops entails more bullets or steel exercised in anger, and thus greater enemy losses. On the other hand, the larger a force that is deployed, the more casualties it can endure before breaking. Larger divisions, for example, can absorb heavier losses before their combat effectiveness is removed. These are the virtues of the 'big battalions' of which Napoleon spoke; this is how larger armies win.[143] And more is always better. Indeed, "The greater the initial numerical superiority, the greater the probability of victory for the stronger nation."[144]

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[141] Cited in Martel, *Foundations*, p322 fn#17.
[142] Cited in M.J. Cohen and John Major, *History in Quotations: Reflecting 5000 Years of World History*, (London: Cassell, 2006), p722. He continued, "If the opposing forces are approximately equal in numbers, in courage, in moral [*sic*] and in equipment, there is no way of avoiding payment or of eliminating this phase of the struggle." As demonstrated by the Somme (1916) and Passchendaele (1917), Haig was more than willing to pay this butcher's bill.
[143] Cynthia A. Cannizzo, "The Costs of Combat: Death, Duration, and Defeat," in J. David Singer (ed), *The Correlates of War: II, Testing Some Realpolitik Models*, (New York: Free Press, 1980). According to Cannizzo's model, "The strength or capability ratio of the antagonists in a war is defined as the ratio of the size of the military forces of the 'stronger' nation to the size of the military force of the 'weaker' nation." More specifically, she describes this number as one determined by the "number of men in the prewar standing armed forces (army, navy, and airforce), excluding reserves, in the year the war began." Cannizzo, "Combat," p239. The strength ratio is measured on an interval scale with 1.0 as its lower limit, and the higher the value, the greater the preponderance of the larger nation over the smaller.
[144] Cannizzo, "Combat," p247.

Attrition as Causal Mechanism

The chief lesson of this tour through the logic of preponderance is that for both the theory's variants the underlying causal mechanism of victory is attrition.[145] "Generally, the side with…the greater incentive and pool of resources with which to keep on fighting—will win."[146] In other words, 'winning' is achieved by gradually reducing an enemy's strength through sustained attack, until the point where only one belligerent remains standing. Haig's description of "wearing-out" the enemy is therefore equally applicable to theories of force size and those of economic wealth. More specifically, the luxury of economic preponderance is that superior wealth makes possible superiority in capital-intensive equipment, such as tanks, airplanes, artillery, and radios. Such an endowment accelerates the rate at which an enemy incurs losses, leaving the prospect of victory more likely for the materially preponderant. Troop preponderance theory is no different, with again the causal mechanism being attrition. A superior weight in numbers permits a grinding down of the opposition, both because of the higher number of losses the preponderant can sustain, and also because outnumbering an opponent speeds up the rate at which casualties are inflicted on the enemy.[147] It is not easy, as

[145] So too does the logic of attrition apply to battles and wars in equal measure. A victory achieved by attrition in war is no different than that obtained in battle. For troop preponderance theory, the aim in both battles and wars is to outlast the opponent by having them run out of able-bodied soldiers first. For economic preponderance theory, the aim is to achieve a greater capital intensity than one's rival, and thus a superior combat performance. In the case of wars, victory in war is simply a matter of possessing a superior material resource base, for that side can out-gun, out-mobilize, and out-last an opponent. Yet so too at the level of battles does the reliance on the superior attritional strength of capital remain, for here is the assumption that the materially preponderant will arrive at the battlefield battle better equipped, and thus able to erode an enemy's strength faster than they endure casualties in return.

[146] De Mesquita, *The War Trap*, p92. What is particularly interesting about de Mesquita's argument is that while he highlights the importance of commitment to a cause, the implicit logic suggests that who actually wins and loses is determined by the relative balance of material capability. Indeed, commitment will either increase or decrease the relative amount of combat resources available to a belligerent, but it will ultimately be attrition that remains the actual causal mechanism of victory and defeat.

[147] Think of, for example, the models of F.W. Lanchester. These equations emphasize numerical preponderance over skill. Indeed, as important as this work is to the matter of quantifying technological effectiveness (qualitative, as opposed to quantitative values), victory is still ultimately on the side of superior numbers. Indeed, Lanchester's 'squares' equations (he squares the values of the numbers) suggest that a force must be the size squared if it is to defeat a numerically superior rival. Here effectiveness and numbers operate in an exponential relationship, meaning more and more superior in skill has to be found to overcome greater numerical inferiority. See F. W. Lanchester,

the catastrophic defeats at Adrianople (378 AD), Manzikert (1071), and Bagration (1944) have shown, to fight effectively when surrounded by a more numerous foe.[148] Preponderance entails more resources with which to kill an opponent and more casualties with which in return can be endured before exhaustion is met. Preponderance is what allows attrition to do its dreadfully bloody work and yet still ensure one side emerges the victor. The winner has enough chemical and physical mass to be last one standing.

The relevance of this assumption should not be underplayed. Indeed, preponderance and its causal mechanism of attrition deeply inform thinking about war and peace in the international system.[149] Regardless of which metric an observer prefers—be it the relative size of armies or economies—preponderance theory and attrition lie at the heart of realist thinking. [150][151] For

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Aircraft in Warfare, (London: Constable and Col, 1916). See also John W.R. Lepingwell, "The Laws of Combat? Lanchester Reexamined," *International Security*, vol. 12 (Summer 1987), p89-133; D.L.I. Kirkpatrick, "Do Lanchester's Equations Adequately Model Real Battles?", *Journal of the Royal United Services Institute*, 130, 2 (June 195), p25-27; Janice Fain, "The Lanchester Equation and Historical Warfare," *History, Numbers, and War* 1, 1 (Spring, 1977), p34-52; James Busse, "An Attempt to Verify Lanchester's Equations," in Benjamin Avi-Itzhak (ed), *Developments in Operations Research*, vol. 2 (New York: Gordon and Breach, 1971), p587-97. Michael E. O'Hanlon, *The Science of War*, (Princeton: Princeton University Press, 2009), p63-124 summarizes the evolution and current state of such mathematical modeling of war. Some more modern theories operate in a similar fashion. See for example, Joshua M. Epstein, *The Calculus of Conventional War: Dynamic Analysis without Lanchester Theory*, (Washington, DC: Brookings Institution, 1985).

[148] See, for example, Hans Delbrück, 1980, *The Barbarian Invasions*, Walter Renfroe (trans.) (Lincoln: University of Nebraska Press, 1980); John Haldon, *The Byzantine Wars: Battles and Campaigns of the Byzantine Era*, (Stroud: Tempus, 2001); Paul Adair*, Hitler's Greatest Defeat: The collapse of Army Group Centre, June 1944*, (Weidenfeld Military, 1994); S. Mitcham, *German Defeat in the East, 1944–5*, (Stackpole, 2007); and G. Niepold, *Battle for White Russia: The Destruction of Army Group Centre June 1944*, R. Simpkin (trans.), (London: Brassey's, 1987).

[149] According to the typology adopted here, if the dependent variable is victory and the independent variable is some sort of metricized yardstick of raw material strength, the theory is ascribed to the preponderance camp. It is true, however, that some scholars, including Clausewitz and Morgenthau, concern themselves with the matter of exhortation or national will. As they observe, raw power must be harnessed to a willingness to fight. Resources must be mobilized before they can ever be deployed to the field. Yet the logic of preponderance remains, as a country's mobilization level is no more than an intervening variable in the power balance equation.

[150] Biddle, *Military Power*, p14. For further connections between realism and preponderance theories, see Michael Howard, "The Forgotten Dimensions of Strategy," in Howard, *The Causes of Wars*, (Cambridge: Harvard University Press, 1983), p101-9; Paul Kennedy, *The Rise and Fall of the Great Powers*, (New York: Random House, 1987), esp pxv-xxv, 536-40; Kennedy, "Grand Strategy in War and Peace: Toward a Broader Definition," in Kennedy (ed), *Grand Strategies in War and Peace*, (New Haven: Yale University Press, 1991), p1-7; Gilpin, *War and Change*, esp p65-66, 123-124 (although this is limited to modern warfare); Joseph Grieco, *Cooperation among Nations*, (Ithaca: Cornell University Press, 1993), p36-50; Jacob Viner, "Power vs. Plenty as Objectives of Foreign Policy in the Seventeenth and Eighteenth Centuries," *World Politics*, 1 (1948), p1-29; Albert O. Hirschman, *National Power and the Structure of Foreign Trade*, 2nd ed (Berkeley: University of California Press, 1980), pv-xx, 3-81.

realists, the "distribution of power will heavily determine when fighting occurs, who will side with whom, and who will win."[152] Military conflict is, after all, seen as a series of "grinding, attritional struggles, with both sides earning victories and defeats." In the end, the final outcome is the "result of cumulative gains made and losses incurred, added up on some 'cosmic toteboard.'"[153] The resolution of military conflict is thus essentially governed by an accounting equation.

Balance of power theory provides a case in point. According to the preponderance camp's logic, stability in the international system is attained by balancing force against force. The strength needed to equalize these relationships is generated either through alliances with like-minded neighbours, or internal efforts to boost military power.[154] Above all, these efforts are a matter of making sure the material *numbers* equal out. In other words, force is represented by material realities—in this case, generally with military size—and thus the number of armies, tank divisions, nuclear missiles, and so on. The implicit assumption here is that superior material

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[151] This observation comes even if some realists would deny it. Part of the problem with realism is that it is often a theoretically murky affair. In particular, realists are rarely explicit when it comes to their explanations of victory. For example, while it is true that classical realists such Morgenthau and Knorr referred in their works to the importance of strategy, ultimately their focus was chiefly on preponderance concerns. Even worse than this contradictory logic is that neither offered a testable treatment of *either* proposition. In fact, it is common for classical realists to ignore military doctrine altogether. Martin Wight, for example, cites the importance of nonmaterial "intangibles," but ascribes them solely to matters of national will, rather than the adoption of particular tactics and strategies to enhance—or diminish—combat power. The only reasonable conclusion to draw, therefore, is that such scholars implicitly accept and ultimately advocate for the preponderance position. See Hans Morgenthau, *Politics Among Nations*, 6th ed, (New York: McGraw Hill, 1985), p141-42; Klaus Knorr, *Military Power and Potential*, (Lexington: D.C. Heath, 1970), p119-36. Martin Wight, *Power Politics*, (Leicester: Leicester University Press, 1978), p26-27.

[152] John Arquilla, *Dubious Battles*, (Washington: Crane Russak, 1992), p10.

[153] Arquilla, *Dubious Battles*, p24.

[154] For the classic expression of how power equality helps reduce the probability of war, see Waltz, *Theory*, p123-28; but also Inis L. Claude, Jr., *Power and International Relations*, (Random House, 1962), p40-93; Arnold Wolfers, *Discord and Collaboration: Essays on International Politics*, (Baltimore: Johns Hopkins University Press, 1962), p122-24; Raymond Aron, *Peace and War*, R. Howard and A.B. Fox (trans), (Garden City, New York: Doubleday, 1966); Morton A. Kaplan, "Some Problems of International Systems Research," in *International Political Communities: An Anthology*, (Garden City, NY: Anchor, 1966), p469-486; Morgenthau, *Politics Among Nations*; Henry Kissinger, *The White House Years*, (Little, Brown, and Company, 1979); and Joseph M. Grieco, 'Anarchy and the Limits of Cooperation: A Realist Critique of the Newest Liberal Institutionalism,' *International Organization* 42 (1988) p485-507.

strength will win the day. The explanatory variable is a number meant to encapsulate some aspect of material strength. It is not technology, not skill, nor even chance. One side must equal the material strength of the other if stability is to be achieved. This is precisely what the land and naval arms race between the European powers hoped to achieve in the years leading up to 1914. The same can be said of Britain's desperate gamble to deter Germany from war with a massive military building program in 1938. So too did this thinking lie at the heart of the Cold War's 'missile race.'[155] In each case, policy was driven by a perceived need to match, if not exceed, a rival's material circumstances. Failure to do so was seen as eminently dangerous, given that inferiority would ensure defeat if hostilities broke out.

It is this straightforward logic that makes preponderance theory so appealing among academics, generals, and policymakers. But it is also the starting point for the theory's staunchest critics. While few deny that troop numbers and economic strength matter a great deal, these forces are much more than inanimate variables. Rather than figures neatly summed in a bookkeeper's notebook, economies sputter from mismanagement, money is spent on guns that often do not work, troops can become lost, and generals have been known to sleep in late. Just because one deploys the largest army in battle does not mean that it will fight hard, let alone competently. Superiority in numbers means nothing when frittered away by poor tactics and technique. Victory is less a matter of the raw numbers involved, but rather how well they are used. So too is there the matter of happenstance and chance. The unpredictable 'fog of war' has befuddled even the most best of armies and the most promising of campaigns. Clearly, numbers alone do not determine the outcome of battles.

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[155] For details on each case, see David Stevenson, *Armaments and the Coming of War: Europe 1904-1914*, (Oxford: Clarendon Press, 1996); J. P. D. Dunbabin, "British Rearmament in the 1930s: A Chronology and Review," *The Historical Journal*, (1975), 18: p587-609; and Paul P. Craig and John A. Jungerman, *Nuclear Arms Race: Technology and Society*, (New York: McGraw-Hill, 1990).

To these charges preponderance theorists have little to say. Most, in fact, simply assume the material in question (whether it be armies or economic product) will be used "optimally."[156] As we have seen, the specific matters of strategy and tactics are not generally discussed by preponderance theorists.[157] Instead, the assumption is that "within reasonable limits of analysis, states make the best possible decisions for attack or defense, taking into account their own and their opponents' options for strategy and force posture."[158] There is no role ascribed for military doctrine and force deployments. This is because labour and capital themselves are deemed the central cause of victory, leaving all other factors to fall by the wayside. Accordingly, the potential for poor generalship, uneven troop quality, and even technological conditions provide the gravest threats to the logic of preponderance theory. In other words, what if the preponderant do not win? What happens if larger armies fail? To do so would be in stark contravention to the theory. We therefore move now to an examination of the historical record, seeking to determine if preponderance theory's parsimonious explanation of victory and defeat finds congruence with the empirical record.

[156] See, for example, Charles Glaser and Chaim Kaufman, "What is the offense-defense balance and can we measure it?", *International Security* (Spring 1998), p55-57. As Biddle notes, "More broadly, all structural IR theory posits that states make optimizing choices guided chiefly by material constraints," rather than any particular conception of good leadership and soldiery. Biddle, *Power*, p249 fn 32. For a further criticism of this position, see Timothy McKeown, "The Limitations of 'Structural' Theories of Commercial Policy," *International Organization*, (Winter 1986), p43-64.

[157] Consider the two biggest empirical databases primarily concerned with preponderance theory: neither the Correlates of War nor the Militarized Interstate Disputes datasets contain any information on tactical arrangements. Instead the focus is on material indices—a very clear indication of preponderance logic at work. See Meredith Reid Sarkees and Frank Wayman, *Resort to War: A Data Guide to Inter-State, Extra-State, Intra-State, and Non-State Wars, 1816-2007*, (CQ Press, 2010) for the latest update from the COW project; and Faten Ghosn and Scott Bennett, "Codebook for the Dyadic Militarized Interstate Dispute Data, Version 3.10," (September 25, 2007), available at http://www.correlatesofwar.org/COW2%20Data/MIDs/MID310.html.

[158] Glaser and Kaufman, "offense-defense," p55.

2.2 Research Design

Hypothesis Formulation & Operationalization

Preponderance theorists contend we can infer combat outcomes purely from material balances. Is this, however, truly the case? Is the central claim of preponderance theory—that the numerically preponderant will use their material advantage 'optimally' and win the military conflicts they engage in—verified by the available data? Does the side with relatively greater material 'power' emerge victorious in armed struggle? To answer, we first must draw from the theory testable hypotheses, then choose a series of related metrics to determine whether or not the hypothesized independent and dependent variables operate in the manner that the theory predicts.

As we have seen, some preponderance theorists emphasize relative economic size, while others prefer troop numbers. Either way, the respective hypotheses are easy to draw. Regarding the latter, the central claim is that when the troop levels of belligerent A are greater than that of belligerent B, victory for A will result. These variables can be tracked in a relatively straightforward manner. The independent variable, army size, is a relatively well-known quantity in the historiography of war, at least when concerning pitched battle. As for the dependent or outcome variable, Clausewitz tells us that victory is best determined by the decision of one side to give up in combat.[159] Victory is therefore most accurately ascribed to the belligerent who commands the field upon day's end.

Moving to economic preponderance hypothesis, the concern here is with the balance in wealth between pugilists. More specifically, when the economic size of A is greater than that of belligerent B, A will emerge from the battle victorious. As for the dependent variable, victory,

[159] Karl von Clausewitz, *On War*, O.J. Matthijs Jolles (trans), (Washington DC, Infantry Journal Press, 1950), p122; and Martel, *Foundations*, p34-5.

the definition of geographic control will once again be used. When metricizing the independent variable, however, the story becomes more complicated the further back into the past the study goes. This is because the study's chronological breadth extends well past the production estimates economic historians have so far been able to compile.[160] Our choice of proxy will thus have to be more nuanced if it is to accurately capture the economic balance between belligerents. To this end, we will have to shift from Gross Domestic Product (GDP) measures of the economic balance between belligerents to population, at least for the period prior to the Industrial Revolution. Although imperfect, this arrangement comes best to meeting the methodological and theoretical needs of the study.

Reliability and Validity of Measures

Troop preponderance theory asks us to track the number of in-theatre combatants over time.[161] Here the most obvious reliability concern is the fact that the estimates offered by historians do not always agree. This tendency to diverge over numbers becomes more acute as the ambiguity of the historical evidence increases. In particular, the longer a battle endures and the larger the battlespace it incorporates, the more the questionable the estimate becomes. In battles as vast as those of the Russo-German War of 1941-1945, the scale involved prohibits easy estimation. Even more problematic, however, is the paucity of evidence from battles long ago. In the most extreme cases, such as those found in Africa, Asia, and pre-Colombian America, there is very little written—and, frequently, even archeological—evidence to work with. The

[160] Angus Maddison, the recently deceased dean of such macromeasurement, has collected regular figures only every 100 years, prior to 1820, and only every 500 years, prior to 1500. Similarly, B.R. Mitchell's data extends no earlier than 1750, and Carlos Sabillon's do much the same. This is not to serve as a criticism of these works, but rather as a reminder that much work remains to be done. Angus Maddison, *The World Economy: A Millennial Perspective*, (Paris: OECD, 2001). Carlos Sabillon, *World Economic Historical Statistics*, (New York: Algora, 2005); B.R. Mitchell, *International Historical Statistics* (3 Vols), (Basingstoke: Macmillan, 1992).

[161] A good discussion of the methodological concerns surrounding military variables can be found in Gary Goertz and Paul F. Diehl, "Measuring Military Allocations: A Comparison of Different Approaches," *Journal of Conflict Resolution*, Vol. 30, No. 3 (Sep, 1986), p553-581; cited at p556-7.

violent struggles of tribal societies do not leave paper trails or shell fragments, nor even a large concentration of arrowheads. Meanwhile, in more modern times, the politicization of body counts during the Vietnam War demonstrates that modern estimates are not free of error either.[162] Leaders throughout history have faced an obvious incentive to embellish military results, regardless of the epoch within which they live.[163] Nevertheless, given the tremendous work of historians to cross-check the battle estimates of ancient writings against the archeological and even geographical evidence, there is good reason for a comparatively high level of faith in the precision of these numbers.[164] Indeed, while oral and written records may be influenced by state propaganda and private boast, the physical remnants and contexts of battle are far more immune to bias. Thus through the confluence of an assortment historical techniques, there generally exists a rough consensus regarding the numbers involved with the great battles of history, at least for those of the Mediterranean, Near East, and Western Europe. Fears of reliability regarding army size can therefore be allayed at least to a degree acceptable to our purposes hear.

It matters not just how we count a variable, but also *what* exactly we are counting. For this study to be valid, troop counts must reflect the same phenomenon—raw power—across time. Only then can the events of the ancient world inform us about those of the present. Fortunately, despite all their historical and cultural idiosyncrasies, armies are more or less like units. One can generally identify the soldiers of an army, regardless of language or costume.

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[162] A discussion of the methodological problems of battle death data construction can be found in Levy 1983, p83-87.

[163] This danger is particularly acute when only one belligerent is in a position to leave behind written records, thereby limiting the potential for dissenting voices recording and disseminating their own version of events.

[164] Meanwhile, note the willingness of Daniel S. Geller and J. David Singer, *Nations at War: A Scientific Study of International Conflict*, (New York: Cambridge University Press, 1998); William Eckhardt, *Civilizations, Empires and Wars: A Quantitative History of War*, (Jefferson, NC, 1992); and Jack S. Levy, *War in the Modern Great Power System, 1495-1975*, (Lexington: University of Kentucky Press, 1983) to embrace these figures. As such, to accept the numbers offered by historians is hardly controversial.

The Ottoman troops who marched on Vienna in 1683 formed columns of plodding infantry remarkably similar to the Pharaohic armies of ancient Egypt, or even Canadian troops outside Kandahar in 2010.[165] Indeed, the Twelfth Dynasty Egyptian armies of 1900 BC stepped off 'by the left', as have every army ever since.[166] This makes the counting of armies relatively straightforward, and, more importantly, suggests a strong sense of conceptual continuity from one millennium to the next. What is left is as the major worry regarding validity is therefore the difference between the highly orchestrated battles of advanced societies and the drawn-out skirmishing of primitive ones. Given that pre-civilization struggles left little written or material evidence—and therefore are not incorporated in the dataset that follows—the applicability of this study's findings will have to be constricted to those contests that did.

We must also consider the reliability and validity of the metrics assigned to economic preponderance theory. In terms of the latter, as we have seen, authors such as Organski have made a persuasive case that the adoption of a parsimonious metric like GNP effectively encapsulates economic potential.[167] Unfortunately, this approach is handicapped by a scarcity of data. Even Maddison's figures for total economic production—the chronologically broadest available—are found at yearly intervals only post 1820.[168] Prior to that, Maddison's data (available as GDP) is limited to the years 1700, 1600, 1500, 1000, and 1 AD. Given that the dataset includes many battles both between these dates and prior to, relying on GDP alone would leave many cases without a proxy to test for the hypothesized relationship. Other arrangements will have to be made if this study's total collection of battle data is to be put to good use.

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[165] For an interesting look at the "perdurability" of ground forces, see John English, *Marching Through Chaos: The Descent of Armies in Theory and Practice*, (Westport: Praeger, 1996).
[166] Dyer, *War*, p12.
[167] See again Organski, *World Politics*,(1968), p358; and above.
[168] And even then, not for all countries. Maddison, *World Economy*. See also Angus Maddison, *Contours of the World Economy: the Pace and Pattern of Change, 1-2030 AD*, (Cambridge University Press, 2007).

Thankfully, there is an alternative metric that can be used to fill in the missing gaps, at least for the period prior to the Industrial Revolution: population.[169] This measure holds promise because prior to the industrial era, population and economic growth advanced in tandem, keeping a relatively common pace.[170] This led Adam Smith to remark that "the most decisive mark of the prosperity of any country is the increase in the number of its inhabitants."[171] The reason for this is because, at the time, innovation could not consistently outpace population growth. Technological advancement occurred in only fits and starts, and therefore never managed to distance itself from population too greatly. Numbers would rise until the new technological ceiling was reached and no more new mouths could be fed. Total population would then hold steady until further advances allowed the process to continue all over again. Absent conditions of sustained innovation, population can be seen as in a perpetual state of 'catching up,' never far from a society's total stock of wealth or total productive capacity. As such, "population and resources develop along more or less parallel lines,"[172] a fact which leaves GDP and population, at least for the epochs used here, as conceptually interchangeable. As a consequence, for the years not covered by Maddison's GDP estimates, population figures will be used as the explanatory variable instead.

The reliability of this approach can once again be considered relatively high. Although far from perfect, these estimates are the product of a concerted effort to adhere to the most fundamental rule of accounting: that the numbers balance. In both matters of population and GDP, great effort has been made to ensure that inputs correspond with outputs. Modern

[169] The standard work is Colin McEvedy and Richard Jones, *Atlas of World Population History*, (London: Penguin, 1978/1985. See also Massimo Livi-Bacci, *A Concise History of World Population*, (Maiden, MA: Blackwell Publishing, 2007).
[170] See, for example, the excellent graph comparing the two in North, *Understanding Economic Change*, (Princeton: Princeton University Press, 2010).
[171] Adam Smith, *The Wealth of Nations*, (London: J.M Dent & Sons, 1964 [1776]) vol.1, p62.
[172] Livi-Bacci, *Population*, p58.

standardized accounts demonstrate this technique admirably, for national output estimates are cross-checked by ensuring that an economy's income (total wages, rents, and profits), demand (the sum of final expenditures by consumers, investors, and government), and production (the sum of value added in different sectors—such as agriculture, industry, and services—net of duplication) all balance out.[173] When they do, we can be reasonably certain the figure is an accurate measurement of the phenomenon under study. Population, too, has been cross-checked in this way. Demographers have spent considerable effort comparing known rates of birth and death against outbreaks of disease, wars, and even peace. What is left for the political scientists is a series of measures whose precision is sufficient for the purposes of this study.[174]

The Sample

The sample's battle data was drawn primarily from Perrett (1996), for it was the most comprehensive (in terms of chronological breadth) and accessible (in terms of summarized deployment and casualty figures). Thereafter, data from Chandler (1997), Badsey (1999), and Clodfelter (2009) were used to add any missing battles and to reconcile gross discrepancies through cross-referencing.[175] Disagreements were resolved by adhering to the more common

[173] This framework can also be expanded to include measures of labour input and capital stock, labour, and total factor productivity. Angus Maddison, *Growth and Interaction in the World Economy: The Roots of Modernity*, (Washington: AEI Press, 2005), p83.

[174] McEvedy and Jones certainly expressed as much: "We have also become confident as the work has progressed that there is something more to statements about the size of classical and early medieval populations than simple speculation. The upper and lower limits imposed by common sense are often much closer together than might be thought. In fact, when all the various fuzzy approaches have been made, one is usually left with an answer that is fairly certain within an order of magnitude…even when there are no data that can be used to calculate a population figure we are far from helpless. There are always guidelines." McEvedy and Jones, *Atlas*, p10-1. See also Sean Clark, "Revealing Clio's Secrets: The Case for Macromeasurement," *The International Journal of Interdisciplinary Social Sciences*, (Volume 4, Issue 8: 2009), p101-114.

[175] Bryan Perrett, *The Battle Book*, (London: Arms & Armour, 1996); David Chandler, (ed), *The Dictionary of Battles*, (New York: Henry Holt and Company, 1987); Stephen Badsey, David Nicolle, and Stephen Turnbull, *The Timechart of Military History*, (Herts: Worth Press, 1999); Michael Clodfelter, *Warfare and Armed Conflict: A Statistical Reference to Casualty and Other Figures, 1494-2007*, (McFarland & Company, 2008); David Eggenberger, *An Encyclopedia of Battles: Accounts of Over 1,560 Battles From 1479 B.C. to the Present*, (New York: Dover, 1985; and R. Ernest Dupuy and Trevor N. Dupuy, *The Encyclopedia of Military History*, (New York: Harper & Row, 1977).

figure. This approach reflects the assumption that the dataset that follows should concur with the conclusions agreed upon by mainstream historiography. The exception, of course, are those instances where the available evidence appears to the author as patently erroneous. In addition, Eggenberger (2008) and Dupuy (1979) were used to clarify attacker and defender, as well as victor and loser, when the other sources left this unclear. As for economic data, Maddison's online study of historical GDP was used, as it is a resource unmatched anywhere for its comprehensiveness and historical breadth. The same can be said of the population resource adopted, that of McEvedy and Jones, done so once again because of its status as the most comprehensive resource of its kind.[176]

A total of 754 battles[177] were collected in the dataset, though the level of data precision and availability for each case is not uniform. The complete collection is publicly available at http://web.me.com/sean_m_c. Unsurprisingly, the earlier back in history, the more likely it was that firm estimates of troop strength are available only for one side. Even so, sufficient data was collected to gather a series of cases that stretched for a 3,500-year period, ranging from Megiddo in 1469 BC, to contemporary operations in Iraq and Afghanistan. Moreover, so far as the author is aware, this dataset constitutes the broadest and most complete collection of battle data available. Such breadth enables the testing of preponderance theory against more epochs than has previously been possible. An example of the data collection and coding efforts, in this case for the troop preponderance hypothesis, is as follows:

[176] Maddison, "Historical Statistics of the World Economy: 1-2008 AD." Available online and in electronic form at http://www.ggdc.net/MADDISON/oriindex.htm; McEvedy and Jones, *Atlas*.

[177] The choice of battles as the unit of analysis is imperfect, but still useful. Speaking of a similar conundrum facing his own study, Biddle noted that "this is an imperfect test: victory in war is not the same as victory in operations per se (my unit of analysis here). Yet the intuition behind the materialist conception of military power draw little distinction between wars and operations—where preponderant material is thought to win wars, it is ostensibly by winning battles." Biddle, *Military Power*, p20-21.

Table 2.1 Dataset Structure (IV: force strength, DV: battle victory).

	Date	Engaged Belligerent Size		Preponderant Win?	
	+/- 0AD	A	B	Data = 1	Yes = 2
Megiddo	-1469.00	Na	Na		
Kadesh	-1294.00	20,000	19,000	1	0
Lachish	-701.00	10,000	8,000	1	2
Acre, Siege of	1189.00	>		1	2
Mohacs	1526.00	25,000	80,000	1	2

*Blue is victor.

We next move to an examination of the causal relationships buried in the data.

2.3 Data Analysis

Having collected the results of 754 separate engagements, we can now look at the relationships between the independent variables offered by troop and economic preponderance theories, and the outcome of victory. Each hypothesis will be examined in order.

H(P)1 ('troop preponderance')

Out of a total of 754 battles in the dataset, 618 cases had sufficient data to test for hypothesis H(P)1, or preponderance theory as measured by troop strength. Included battles ranged from Kadesh (1294 BC) to Wanat (2008). Of these cases, however, only 287 confirmed the preponderance hypothesis. In other words, in only 287 of 617 battles did the larger army (as determined by peak battle deployment numbers) emerge victorious. This computes into a mere 45.4% of all available engagements, meaning that less than one out of every two preponderant

armies in the sample won. For every occasion where the numerically preponderant trounced its rival, such as the overwhelming Soviet force at Stalingrad (1942), there exists a case representing the opposite dynamic, such as Yellow River (1226), where an army numerically inferior nevertheless defeated its opponent. In the latter case, no more than 180,000 Mongol troops proved sufficient to utterly destroy the 300,000-strong Hsia army that stood in its way to southern China. Overall, the explanatory efficacy of preponderance hypothesis H(P)1 is thus *less* than a coin toss. Indeed, when history is examined in its totality, a preponderant army is just as likely to correctly call heads as it is to win in battle. This is a rate of success only the foolhardy should find comfort in.

Although the theory does not predict this, there is the potential for a historical skew in the data. If, for example, preponderance played a role entirely counterproductive to victory during the Renaissance, and yet conformed to the predictions of troop preponderance theory elsewhere, a glimmer of hope for troop preponderance theory would remain. In other words, it would not be completely falsified. The best way to account for this potential is to disaggregate the above results into distinct epochs (fig 2.2). To do so, however, will require the division of cases into units of differing historical breadth. This is because the pre-modern era is particularly short on battle data, and therefore requires larger blocks of time to arrive at a statistically-relevant number of cases than the present. Despite this modification, we need not worry about damage to the study's validity because of the relatively slow pace of political, social, and economic change in premodern times. The glacial pace of agricultural productivity growth provides a useful illustration of this point, for improvement in crop yields accelerates noticeably only with the advent of the industrial revolution.[178] The millennium-length intervals used for the first two

[178] See, for example, Mark B. Tauger, *Agriculture in World History*, (London: Routledge, 2011) and G.J. Leigh, *The World's Greatest Fix: A History of Nitrogen and Agriculture*, (Oxford: Oxford University Press, 2004).

samples are thus both convenient for data provision and sufficiently long enough to illustrate the broad dynamics of the pre-industrial age. Meanwhile, from roughly the Enlightenment onwards, it becomes both possible and necessary to divide the periods into smaller units of time. From about the early Renaissance, then, the periods are reduced to 200 years apart, and then 100 years, when more data becomes available.

Table 2.2 Preponderance Success (defined as the numerically superior belligerent, disaggregated by period).

	Pre-0 AD	0 AD - 1299	1300-1499	1500-1699	1700-1799	1800-1899	1900-1999	2000-present
Total Battles	29	33	40	62	78	167	204	5
Prepon't Wins	6	10	16	27	34	76	116	2
%	*20.7*	*30.3*	*40.0*	*43.5*	*43.6*	*45.5*	*56.9*	*40.0*

*Based on results of 617 cases. Standard deviation of % totals: 10.74; mean: 40.1.

The story that emerges from the data is an interesting one. Out of a total of eight separate historical epochs, preponderance theory manages to accurately predict more than 50% of battle results just once. Only in the 20thC century, where 57% of preponderant armies emerged victorious, did preponderance offer a belligerent better than even odds of winning. In contrast, the results downplaying the role of preponderance were quite consistent. With the exception of the 1900s, from the year 1300 to the present saw the returns to preponderance remain mired in

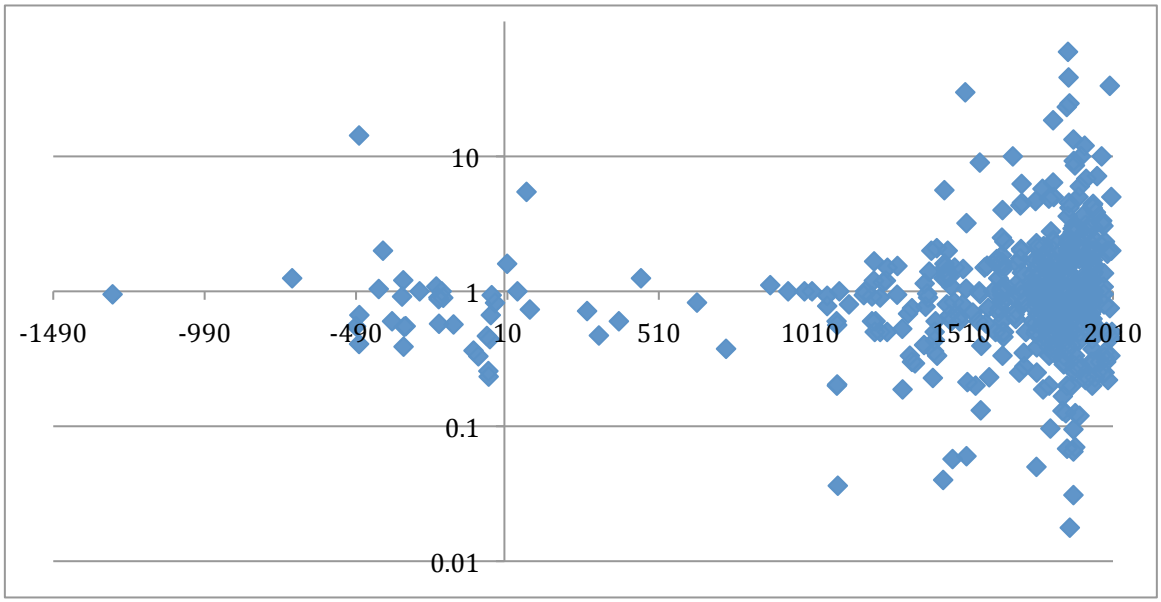
the mid-to-low 40s%. Overall, despite a gently upward-sloping improvement over time,[179] the historical norm is thus for the belligerent enjoying troop preponderance to in fact *lose* the engagement, a result precisely the opposite of what the troop preponderance theory predicts. Indeed, the failure of numerical superiority spans not only the many battles of antiquity were highly-advanced-yet-outnumbered armies fought their barbarian rivals, but also more recent centuries, where relative social and technological parity was the norm. The distinctions between the armies of Napoleon, Wellington, and Kutuzov, for example, paled in comparison to those between Roman and Goth. Yet preponderance has remained of little aid even in more modern times. For most of history, enjoying superior military strength can be at best seen as of dubious causal significance; at worst, as a burden or curse.

The sheer ambiguity of the connection between preponderance and victory is best illustrated by scatterplotting the victor:vanquished ratio over time (fig 2.1). This ratio is simply the balance in the force size between victor and vanquished, measured in terms of the victor. For example, at the battle of Kadesh (1294 BC), where the victorious Hittites were outnumbered by their Egyptian foes by 19,000 troops to 20,000, the ratio stands at 0.95. That this number is less than 1.0 reflects that it was in this instance the numerically *inferior* that emerged victorious. In all, we have enough data to examine 524 cases in this manner. When plotted graphically, preponderance theory anticipates the dataplots will be found to be consistently above the 1.0 line on the y-axis. The more that lie above, the greater the number of instances where the victorious belligerent was numerically superior to the vanquished. Unfortunately for the theory, the

[179] It is possible that this trend reflects slowly improving command and control capabilities. What makes such a conclusion tenuous, however, is that between the fall of Rome and the imperial staffs and telegraphs of the 1800s, command performance would likely have been as chaotic and undisciplined as any other social organization of the day, at least in comparison to the smoothly professional institutions of high antiquity. This collapse and return of command ability displays little congruence with the linear improvement in preponderance performance observed here. For further reading, see Martin Van Creveld, *Command in War*, (Cambridge: Harvard University Press, 1985).

evidence does not bear this out. In stark contradiction to preponderance theory's (HP1) prediction, as many plots can be seen below this line as above. This remarkably even distribution both above and below indicates that the numerically inferior are just as likely to win an engagement as the side with the larger army. Such a result is something the theory most definitely does not predict.

Figure 2.1 Victor:Vanquished Preponderance Ratio (relative size of victor, as measured by peak troop deployment & date).



*Note: logarithmic scale. Based on 526 cases. Median: 0.93107; Standard deviation: 4.19363.

It is important to note just how varied and random the association between relative troop strength and victory is. Armies numerically superior to their opponents have sometimes used their advantage in troop strength to grind out victory, such as the Persians at Thermopylae (480 BC; 14.3 victor-vanquished troop ratio). There, in a narrow pass along the Aegean coast, king

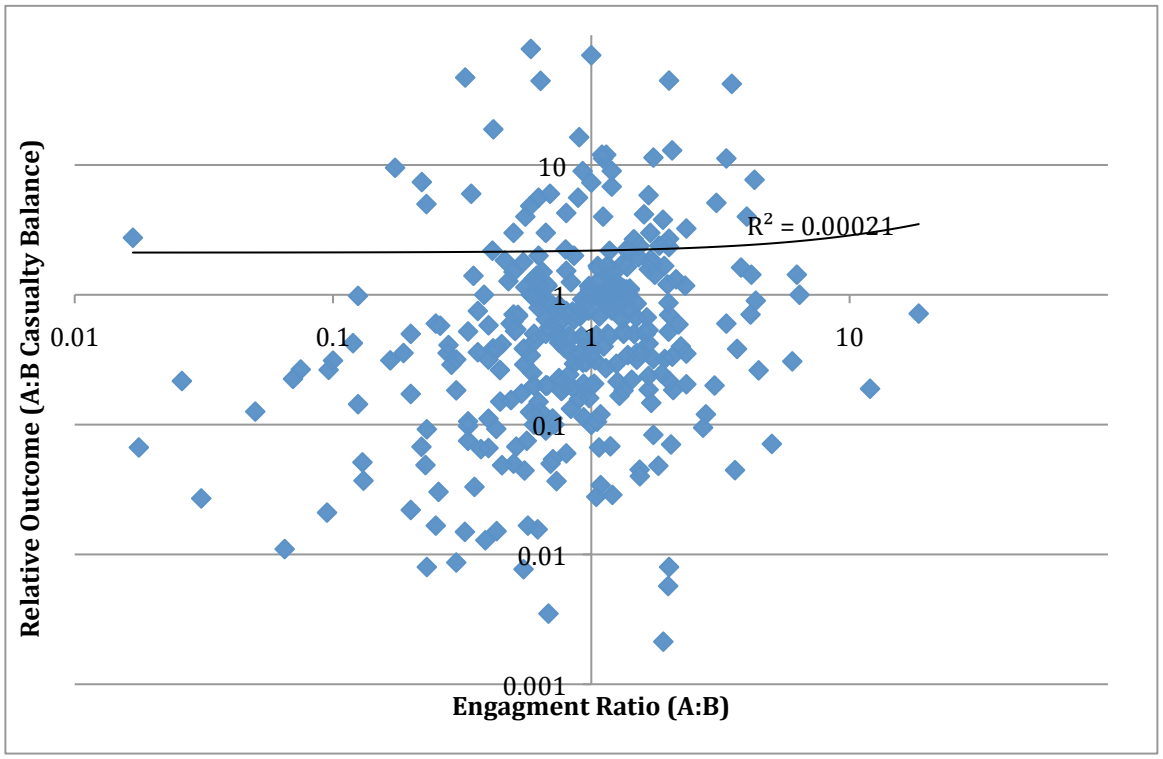
Xerxes enjoyed sufficient numerical superiority to overcome the Greek defender's advantages of geography, motivation, and individual skill. After three days of brutal fighting the tiny Greek garrison was forced to concede to superior Persian numbers. In other cases, however, decisive numerical advantage appears to have played no part in victory whatsoever. Caesar was surrounded by an army at least four times his own at Alesia (52 BC; 0.23 ratio), yet these numbers were overcome in brilliant fashion by a combination of methodically-prepared defensive works and a surprise attack on the rear of Vercingetorix's relief army. Gallic preponderance could not halt the Romans' and their march of brutal conquest. More importantly, this apparent disconnect between preponderance and victory has remained consistent over time. Numerically inferior armies have carried off major victories everywhere from Issus (333 BC), where Alexander himself led a decisive cavalry charge that broke the Persian lines, to Suomossalmi (1939), where devastating Finnish rear-guard attacks destroyed the impetus of the Soviet's advance. This is problematic for troop preponderance theory because, as illustrated in figure 2.1, the numerically inferior have proven just as apt at winning battles as the preponderant.

A final method of testing the relationship between troop strength and victory requires altering the dependent variable slightly. As stated at the outset, are concern in this study is victory as defined by geographic control of the battlefield. Unfortunately, this win/loss measure is a categorical variable, and therefore does not avail itself well to scatterplots and inferential statistics. If, however, we accept a more imperfect measure, we can examine this relationship, keeping these important caveats in mind. More specifically, we can use the balance in casualties between belligerents as a rough measure of relative performance. It is true that some armies are much more tolerant towards casualty acceptance than others (consider the Soviets in 1941

against the Americans in 1991 or 2003 Iraq), it is fair to assume that losing troops is not a military's ideal circumstance. In regards to preponderance theory, comparing casualty balances with engagement ratios should result with a notable trend line running from the top left quadrant, with low engagement ratios (meaning belligerent A is numerically inferior) and a high number of casualties vis-à-vis the enemy, to the bottom right quadrant, with high engagement ratios (meaning the belligerent was numerically superior) and a casualty balance that less than one casualty incurred for each of the enemy's. In other words, as a belligerent's relative size increases, the proportion of casualties it endures should fall.

The results in figure 2.2, however, demonstrate that this is decidedly not the case. The scatterplots are randomly distributed. This is demonstrated both visually and with an OLS trend line offering a miniscule R2 of 0.00021. Through this we can see that the value of troop preponderance is highly ambiguous. Armies have commonly won when they were ten times greater their opponents, but so too have they won when they were just one-tenth. Given these and the findings above, the claim of troop preponderance theory cannot be sustained by the empirical evidence.

Figure 2.2 Force Size Ratios & Relatives Outcomes (A:B strength vs A:B casualties).



*Note: logarithmic scale. Based on 346 cases. Pearson coefficient: 0.014; Standard error: 0.003. *P-value*: 0.79.

H(P)2a ('economic preponderance': population)

Out of a total of 750 battles in the dataset, 633 had sufficient data to test for hypothesis H(P)2a, or preponderance theory as measured by material resources, with population as proxy. Of these, 336 cases confirmed the preponderance hypothesis. In other words, in 336 of 633 battles studied, running from rebellion against Egypt at Megiddo (1469 BC) to NATO and its Taliban opponents during Operation Achilles (2007), the wealthier belligerent—as determined by population totals—emerged victorious. This computes into a bare majority of just 53.1% of all possible battles, which is once again hardly a ringing endorsement of the theory. Indeed, although the preponderant are at least now more likely to win the battles they fight than lose, the effect of material supremacy is decidedly marginal. The returns to preponderance and now more

than a coin flip, but only just. When history is examined in aggregate, economic size is anything but a guarantee of military success.

Perhaps, however, the importance of material preponderance has varied over time. To account for this potential, we can once again disaggregate the data into a series of statistically relevant, but also historically appropriate, epochs (table 2.3). The results tell an interesting story. Unlike the slow, gradually upward trend in the returns to troop preponderance, the utility of wealth to military endeavours has been much more variable throughout history. The performance curve is in fact decidedly jagged, with the importance of material preponderance (again, measured here by population) rising and falling in three distinct waves. Twice in history the causal success of material preponderance reached 60%, indicating at least some clear favourability in results towards the materially preponderant. The epochs of late antiquity/medieval and the 20th century did at least offer a slight advantage for the materially preponderant. At its peak efficacy, H(P)2a is at least a somewhat noticeable improvement over the coin toss.

Table 2.3 Economic Preponderance (defined as the economically superior belligerent; population as proxy).

	Pre-0 AD	0 AD - 1299	1300-1499	1500-1699	1700-'99	1800-'99	1900-'99	2000-present
Cases	34	63	30	40	73	158	228	8
Prepond't Wins	13	39	9	20	30	86	135	4
%	*39.4*	*61.9*	*30.0*	*50.0*	*41.1*	*54.4*	*59.21*	*50.0*

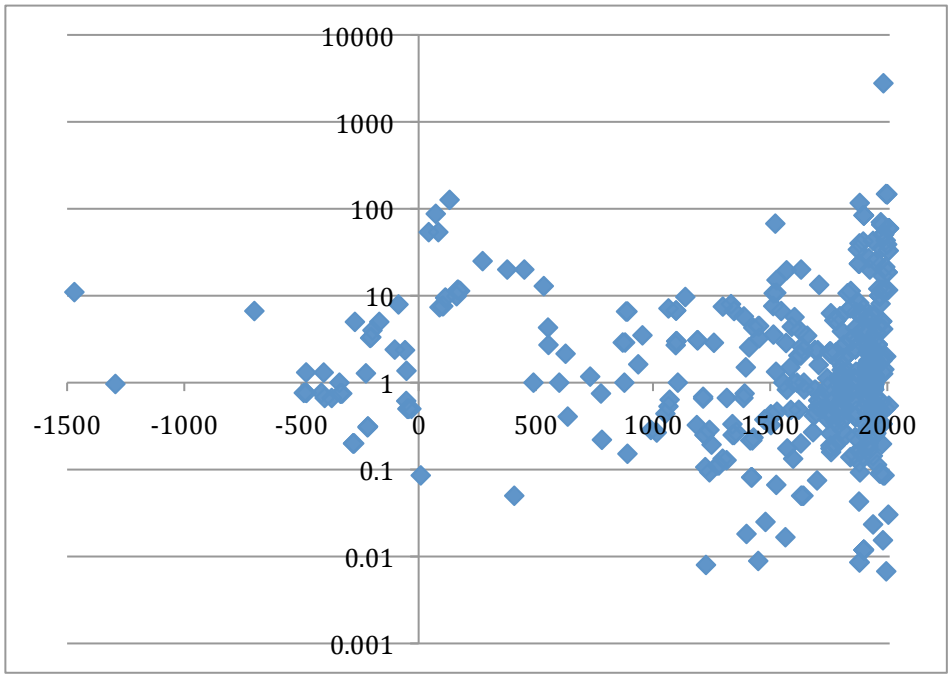
*Based on results of 633 cases. Mean of total % figures: 48.25125; standard deviation: 10.77629.

The problem, however, is the variability in the results. Unlike troop preponderance theory, which could claim a slow, but relatively steady increase in its causal efficacy over time—at least until the statistically insignificant 21st century—material preponderance appears to go from peak to trough. Following each tolerable showing, the relevance of material preponderance to victory retreats to even less impressive heights. Something in the early Renaissance, for example, reduced the potency of capital-intensive armies almost completely. But it was not economic size. Unlike during the preceding epoch, material preponderance provided almost no assistance to armies throughout the 14th and 15th centuries. Yet by the 1900s, the materially preponderant were back to winning almost 60% of the time. This suggests a great degree of variability in the causal import of material preponderance. In other words, the theory's independent variable appears to not be particularly independent after all. Something else must therefore lie as the ultimate cause of victory and defeat. Worse, however, is that the results lack a systematic trend in one direction. Whatever exogenous causal force is manipulating the relative importance of material preponderance—be it technology, political sophistication, military acumen, and so forth–it is not doing so consistently. As is, the results here appear arbitrary and are therefore theoretically suspect.

Reinforcing this conclusion is a scatterplot of the victor-vanquished ratio data. Just as above, this graph is a reflection of the material balance (with population as proxy) between a battle's winner and loser. Thus at Lake Trasimene (217 BC), where the victorious Carthaginians were backed by a population of 1.5 million against Rome's 4.8 million, the preponderance ratio was 0.31. In other words, we can reasonably assume that the Carthaginian economy was not quite a third of Rome's when Hannibal thrashed the legions of Gaius Flaminius. More importantly, should preponderance theory be proven correct, the dataplots must once again be

consistently found *above* the 1.0 line on the y-axis. Yet here we find a similarly dramatic inconsistency in the results. With the exception of the 500 years of the Roman Empire's height,[180] battles throughout the dataset are almost as likely to be won by the materially *inferior* belligerent as the preponderant. The relatively even distribution of dataplots above and below the line of equality leave preponderant belligerents little hope that their victory in battle is in any ways assured. Unlike the theory's assertion, the materially inferior do win—and win a great deal of the time.

Figure 2.3 Victor-Vanquished (Population) Ratio (relative size of victor, as measured by economic size/population).



*Note: logarithmic scale. Based on 665 cases. Median: 1.11; Standard deviation: 151.79.

[180] Of 19 battles in the dataset found between 0 and 500 AD, 18 involved the Roman Empire, fighting either neighbouring or internal rivals.

The erratic nature of these results indicates that population preponderance does not work in the universal manner its proponents assume. Most urgently, it offers no explanation as to why such variability in causal importance exists in the first place. Nowhere in the logic of attrition is there the suggestion that it should operate more effectively in some circumstances than others. In contrast, the theory contends that superior numbers will prevail regardless of the circumstance; that is the heart of preponderance theory's parsimonious claims. That they do not deeply undercuts the theory's explanatory power.

H(P)2b ('economic preponderance': GDP)

As useful an approximation of national wealth as population is, it works as an unbiased proxy only until the onset of the industrial revolution. That its utility diminishes is because the commercial and technological innovations associated with late 18th and early 19th centuries enabled economic growth to outpace population growth for the first time. More importantly, this decoupling of population and economic product emerged in different geographic regions at different times. Great Britain's economic transformation came first, followed in turn by Western Europe and the European offshoots, then Latin America and East Asia. These time lags deal a blow to the validity of the population measure. Until this time, population could be counted on as a rough reflection of aggregate economic potential. However, from the industrial revolution onwards we can no longer be as confident because we are no longer dealing with like units, at least when comparing regions of varied economic development. In other words, for most of human history, per capita wealth remained relatively the same.[181] When it was, population works as a fine proxy for relative wealth between two powers. But when per capita wealth is not, population alone tells an insufficient story. In this way population comparison for the

[181] See Maddison, online. The bifurcation between North and South slowly began to emerge in the 1500s, but did not take off until the Industrial Revolution was well under way.

battles of the various Franco-German Wars, where both combatants were roughly equivalent in per capita wealth, is methodologically sound. Yet to use the population metric to gauge the struggles between France and Algeria after the Industrial Revolution began to transform the French economy would underplay the actual degree of material difference between the two belligerents, given that their level wealth per person had by now become dramatically different.

To control for this data validity problem we shift now from population to GDP estimates.[182] Although by no means perfect, these figures provide a remarkably precise view of the relative material balance between two belligerents. The chief limitation of GDP data is that it is far scarcer than population estimates, and thus is generally limited to recent times. Given the difficulties of valuation and the relatively ephemeral nature of most goods, estimates of economic production are far more onerous to assemble than those of population. Even so, a total of 409 battles were able to be tested for hypothesis H(P)2b, or preponderance theory as measured by material resources (GDP). To be clear, the majority of these were found in the years following 1820, a time when the Industrial Revolution was now firmly underway. Of this decidedly modernity-skewing sample, 254 cases confirmed the preponderance hypothesis; that is, in 254 of 409 battles the wealthier belligerent (as determined by GDP totals) won. This computes to 62.1% of the engagement total, and serves as a noticeable improvement over the casual success rates of the previous hypotheses. This result does not, however, stray far from the earlier concerns of causal ambiguity. No general can afford to sleep soundly when relying on odds in the neighbourhood of 60%.

To test for the possibility possible that wealth facilitates victory to a greater extent in some eras as opposed to others, we can disaggregate the data into six epochs and examine the consistency of the results. All data prior to 1820, totaling just 32 available cases, is grouped

[182] Angus Maddison, online.

together to establish a baseline for pre-industrial results. Thereafter, the results can be separated into roughly 50-year intervals, leading up until the present day, and compared accordingly.

Table 2.4 Economic Preponderance (defined as the economically superior belligerent; GDP as proxy).

	Pre 1800	1800-'49	1850-'99	1900-'49	1950-'99	2000-'06
Cases	32	59	91	159	59	9
Prepond't Wins	14	36	56	92	50	6
%	*43.8*	*61.0*	*61.5*	*57.9*	*84.7*	*66.7*

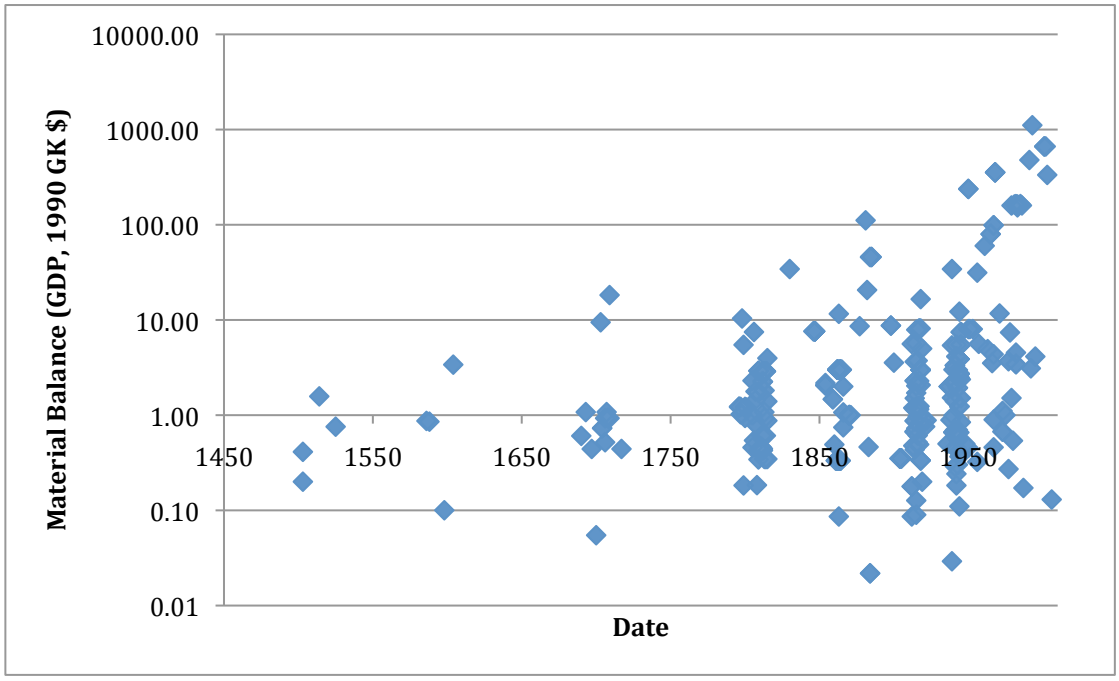
*Based on results of 409 cases. Mean for % totals: 62.6; standard deviation: 13.30053.

The findings present an interesting story. Once again it appears that, prior to the industrial revolution, economic preponderance played very little role in achieving victory on the battlefield. Although this conclusion is admittedly based on a limited sample of just 32 cases, almost 60% of victorious belligerents in this period enjoyed *less* economic wealth than their defeated rivals. Rather than the key to victory, superior wealth in this era appears to have been a dangerous encumbrance. Nevertheless, once the industrial revolution took place the evidence suggests that a preponderance of material wealth played a useful—albeit limited—role in securing victory. Between 1800 and 1950, the causal success rate of material preponderance (GDP) remained in the neighbourhood of 60% per epoch, which was roughly the average of all results in aggregate. While this is hardly an overwhelming result, the theory can claim during this century and a half to being more correct than not, a modest boast that sits in stark contradiction to the previous variations of the theory examined above.

Even more impressive is the latter 20th century, which provides by far the most compelling example of congruence between theoretical prediction and empirical outcome. Of the 59 recorded battles fought between 1950 and 1999, victory went to the materially preponderant (as measured by GDP) roughly 85% of the time. This epoch's results are a strict departure from the historical norm, both in light of the other epochs assessed according to the predictions of H(P)2b, as well as the alternative hypotheses studied here as well. From 1950 onwards, the materially-preponderant have won their battles with a greater frequency than professional NBA basketball players make free throws.[183] A result in excess of 80% is therefore indicative of a very powerful degree of correlation between the independent and dependent variables hypothesized by the theory, at least for the postwar era. [184] In the latter half of the 20th century, the bigger battalion finally became king.

[183] "Since the mid-1960s, college men's players have made about 69 percent of free throws, the unguarded 15-foot, 1-point shot awarded after a foul. In 1965, the rate was 69 percent. This season, as teams scramble for bids to the N.C.A.A. tournament, it was 68.8. It has dropped as low as 67.1 but never topped 70. In the National Basketball Association, the average has been roughly 75 percent for more than 50 years. Players in college women's basketball and the W.N.B.A. reached similar plateaus—about equal to the men —and stuck there." John Branch, "For Free Throws, 50 Years of Practice Is No Help," *New York Times*, (March 3, 2009). The professional mark of 75% stands as a useful threshold for the of this study. Free throws are seen as pretty close to a 'sure thing,' yet with an appreciation that events sometimes go awry. Policy makers can ask for no better or more realistic level of certainty.
[184] Another standard to use is the advantage the home side enjoys in team sports. In Major-league baseball, 54% of games are won by the home team. In international cricket, the figure is 60%; in English Premier League soccer 63%, and 69% at the US collegiate level. *The Economist*, "The referee's an anchor," (March 12, 2011), p90. Based on data from Tobias Moskowitz and Jon Wertheim, *Scorecasting: The Hidden Influences Behind How Sports Are Played and Games Are Won*.

Figure 2.4 Victor-Vanquished (GDP) Ratio (relative size of victor, as measured by GDP).



*Based on results of 362 cases. Logarithmic scale. Median: 1.51; standard deviation: 97.40.

A scatterplot of the material balance between victor and vanquished illustrates how the prospects of the materially-preponderant have dramatically improved over time. Prior to 1800, the plots are just as likely to be found above the line of material equality (1.0 on the y-axis) as below. This indicates that the battlefield influence accorded to superior GDP was at the time highly ambiguous. As the nineteenth century progresses, however, the balance of plots slowly begins to shift in a manner favourable to the theory. After 1950 in particular, the balance of plots can be found well above the equality line. This indicates remarkable congruence between the evidence and the theory's central prediction, at least for this period. Indeed, from roughly the

Second World War until 9/11, the materially preponderant were almost assured victory on the battlefield.

An Interesting—But Confounding—Anomaly

That H(P)2b does so well in this particular epoch is worthy of praise. But before too many laurels are awarded, we must consider the unexplained riddles that remain. What is particularly disconcerting is that this spike in explanatory efficacy is such a departure from previous results. A plausible explanation can, however, be found within the seeds of preponderance theory. Economic theories of attrition contend that building new armies and lavishing them with capital-intensive weaponry brings victory. Favourable rates of attrition are attained by the side with bigger guns and more radios. Thus as the potential of capital grows, so too should its importance on the battlefield. Given that the lethality of a modern army 100,000 strong is 2,000-times greater than one of antiquity,[185] it is fair to posit that capital plays a much greater role on the contemporary battlefield. Indeed, capital-intensive weaponry played a much more prominent role during the American advance on Baghdad (2003) than Alexander's crossing of the Granicus (334 BC). Modern armies rely on sophisticated equipment, such as cruise missiles, wireless communication, and GPS systems, as never before. We should therefore expect the preponderant to perform better in the modern, substantively different age.

The problem, however, is that the introduction of capital intensity to the battlefield occurred long before the materially preponderant started to win with any degree of certainty. The preliminary bombardment at Passchendaele (1917), for example, saw 120,000 British gunners fire 4.3 million shells—or 107,000 tons of explosive—at German lines over 19 straight

[185] Trevor Dupuy, *Attrition: Forecasting Battle Casualties and Equipment Losses in Modern War*, (Falls Church: Nova Publications, 1995), p29.

days.[186] The Great War was therefore obviously not short on capital. In fact, the material situation facing Haig at the Ypres salient was far more akin to that of Petraeus in Kandahar (2010) than Scipio at Zama (202 BC), or even Napoleon at Wagram (1809). Yet unlike during the postwar era, material preponderance did commanders in this period little good. Despite the almost massive amount of resources at the Entente's disposal, the returns to preponderance in the 1900-49 period were less than a 60% chance of victory in all three versions of the theory. If a surfeit of capital is to explain the postwar anomaly, a similar abundance in earlier eras should have led to similar outcomes there as well.

We can measure capital's stunning transformation of the battlefield in other ways as well. Foremost is the effect of industrialization on army lethality. Following the industrial revolution, technology and wealth advanced in tandem, furnishing military commanders with a previously unimaginable degree of destructive power. A typical army of WWI, for example, was roughly 116 times more lethal than its equivalent in antiquity, 42 times than that of the days of Napoleon, and even 16 times more lethal than a comparable army in the US Civil War.[187] In contrast, the armies that followed were much more modest in their improvement in the ability to kill. A typical army of World War II was only 5.5 times more lethal than one of the preceding Great War, and an army of the late 1980s just 3.2 times more lethal than that of World War II. In other words, while the German army of 1945 would have had at least a fighting chance against its 1980s equivalent, the Prussian forces of 1870 would have run roughshod over even the best armies antiquity had to offer. The great leap in battlefield lethality thus occurred not in the postwar era—where economic preponderance theory performs rather well—but at least a half-

[186] John Nef, *War and Human Progress*, (New York: W.W. Norton, 1950), p366.
[187] Calculated from Dupuy, *Attrition*, p31.

century *earlier*. Unfortunately for preponderance theory, while capital may have transformed the battlefield, it did so long before the fates of the economically preponderant became so favoured.

Consideration of military spending per soldier tells a similar tale. The capital-intensive nature of the postwar age can be demonstrated by observing British military expenditure. Between 1950 and 1998, the relentless cost of increasing technological sophistication drove spending from 22,000£ per serviceman to 105,500£, an increase of 480%. Yet in historical comparison, such growth in capital intensity hardly looks radical. Supported by the nation's burgeoning industrial and financial wealth, British military expenditure per serviceman grew from 2,700£ in 1850 to 12,900£ in 1900—a jump almost identical to the previous figures.[188] Regrettably for the poor shilling-a-day Tommy Atkinses, most of this extra funding did not go into pay, but rather to ever more elaborate capital-intensive weaponry and equipment.[189] In other words, we again see how a growing capital intensity in military affairs long pre-dated the post-war era. Indeed, if capital transformed the battlefield to a degree that 85% of the economically preponderant won the battles they fought, it did so long before 1950. Why, then, did all the material wealth fail to ensure victory to the same startling degree in these earlier decades as well? Why would attrition work well in one era and not the other, particularly when the dramatic influence of capital can be demonstrated in both periods?[190] To this preponderance theory offers no answers.

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[188] Niall Ferguson, *The Cash Nexus*, p33, 35. Measured in 1998 prices.

[189] See, for example, Allan Mallinson, *The Making of the British Army*, (Bantam Press, 2009); Alan Ramsay Skelley, *The Victorian Army at Home: the Recruitment and Terms and Conditions of the British Regular, 1859-1899* (Taylor & Francis, 1977); Edward M. Spiers, *The Late Victorian Army, 1868-1902*, (Manchester University Press, 1992).

[190] There is the potential that the effect of capital intensity on battlefield outcomes is felt not in a linear fashion, but an exponential one. This would explain why the improvements demonstrated in the 1850-1900 era (with causal efficacy rising to roughly 60%) did not take off until the 1950 period, where the return to economic preponderance hit 85%. There is nothing in the logic of preponderance, however, that suggest attrition should work moderately well at one level, and then exponentially better beyond a particular threshold.

Table 2.5 Lethality Trends of Ground Armies (based on Dupuy's Theoretical Lethality Index, TLI).

Typical Army of 100,000	Lethality Area (km2)	Lethality TLI in mils	Avg Compared to antiquity	Lethality per m2
Antiquity	1	2.0	1.0	2.00
Napoleonic Era	20	5.5	2.8	0.27
American Civil War	26	14.3	7.2	0.55
WWI	250	233.0	117.0	0.94
WWII	2,750	1,281.0	641.0	0.47
1973 Oct War	3,500	1,650.0	825.0	0.47
Europe, 1985-90	5,000	4,098.00	2,049.00	0.82

* Dupuy (1995), p31.

2.4 Conclusions

Summary & Review

The purpose of this chapter has been to measure the causal efficacy of preponderance theory in each of its basic forms. When judged against a large-*n* series of cases spanning some three millennia, the results can hardly be considered encouraging for any of the theory's proponents. Of the three hypotheses tested, none demonstrated an overwhelming relationship between an abundance of resources and victory on the battlefield. Folk wisdom fared worst, with more than half of all battles being won by the side numerically *inferior*. Not even the historical trend of slowly increasing returns to troop preponderance can overcome the fact that even in the best of circumstances the advantage conferred by 'bigger battalions' is slight. Never did the probability that the numerically preponderant will emerge victorious exceed much more

than that of a coin toss. At worst, a preponderance of soldiery appears to be more a cumbersome burden than the key to battle victory.

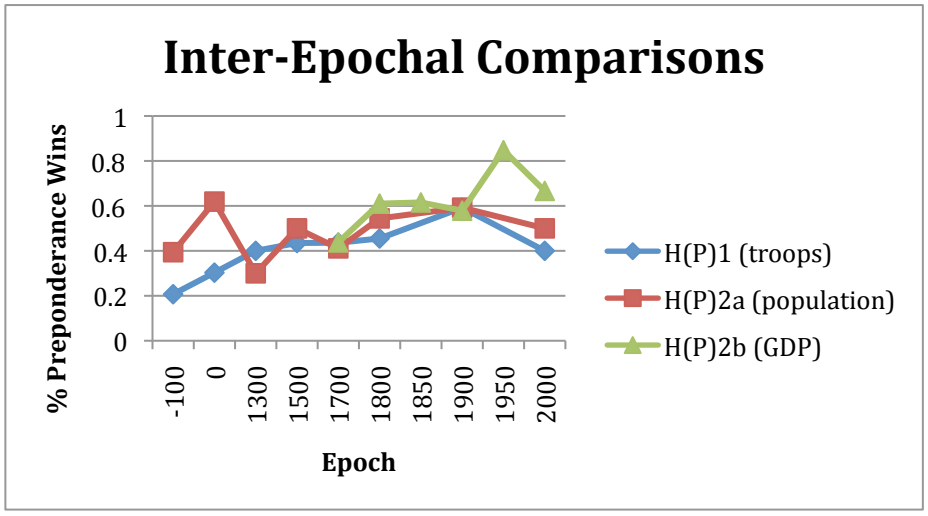
Table 2.6 Preponderance Results (% of battles where preponderant was victorious, by hypothesis & metric).

Hypothesis	Causal Metric	Aggregate Causal Success	Total Cases
H(P)1	Troop preponderance.	46.5%	617
H(P)2a	Economic preponderance (population).	53.1%	633
H(P)2b	Economic preponderance (GDP).	62.1%	409

Economic preponderance theory offers little to boast about, either. When the relative material balance is measured using population as proxy—thereby allowing us to travel further back in time—the aggregate results indicate that the preponderant belligerent has won just 53% of the time. As scatterplot 2.2 clearly shows, for every preponderant army that wins there is almost assuredly one that loses. Even worse is the high degree of unpredictability associated with the results. As figure 2.4 makes clear, the line H(P)2a is jagged, suggesting that the yields to economic supremacy are not consistent over time. This result is not only in stark contrast to what the theory predicts, but also validation of the choice for the study's comparatively long chronological scope. Attrition should benefit the strong regardless of the circumstances, yet the current literature is too historically narrow to allow for the potential that it does not. H(P)2b faces a similar degree of unhelpful variability. Here economic preponderance is measured with estimates of GDP, a technique particularly useful for the modern era. Unfortunately, the

aggregate returns on material superiority improve to just 62% of all battles fought, a number that remains far less than a ringing endorsement. Moreover, when the results are disaggregated by epoch, some eras again appear more amenable to victory by the preponderant than others. The postwar era, for example, enjoys a striking 85% return on GDP preponderance, which is by far the most impressive result observed. Yet this spike in predictive success cannot be ascribed to the causal mechanism offered by preponderance theory—capital intensity on the battlefield—for capital transformed the battlefield long before those with a preponderance of it starting winning. The causal effect of preponderance can therefore only be deemed ambiguous.

Figure 2.3 Inter-Epochal Comparisons (% preponderant wins, by metric, disaggregated by epoch).



*Note: timeline is not to scale.

The chief lesson of these weak results is that a reliance on preponderance to secure victory is not much more useful than leaving one's fate to chance. Even the 85% result achieved by economic preponderance (GDP) for the postwar era is more a theoretical anomaly than part of a consistent trend of accurately predicting battlefield outcomes. This lack of a match between

logically deduced 'empirical statements' and the accumulated evidence provides a severe blow to the theory's credibility. In short, the results of this study indicate that the causal mechanism of attrition does not work in the manner predicted by preponderance theorists. As we shall see, this is a greater problem than is commonly assumed.

The Problem with Preponderance

The most disconcerting aspect of preponderance theory is not its lack of causal efficacy. Indeed, many international relations theories face a serious disjuncture when faced with the empirical record.[191] It would therefore be unfair to single out preponderance for its failings in this regard. Instead, what is so dangerous about the theory is the popularity of its associated causal mechanism, attrition. It is, after all, one thing for a theory to remain no more than a topic for discussion in musty academic debates; it is something entirely another, however, to be taken as an article of faith by generals mired stalemate, unsure of where else to proceed—particularly when the evidence suggests that the concept is murderously unreliable. Indeed, the fashionability of preponderance and attrition should give reason for great discomfit precisely because of the deadly repercussions when they do not work.

No struggle demonstrates this dilemma with greater poignancy than the battle of Verdun (1916). This was, after all, an engagement whose expressed purpose was to achieve victory through attrition. With the Russians checked in the East after Gorlice-Tarnow (1915), the German Chief-of-Staff Falkenhayn considered the time ripe to resolve the deadlock in the West. With the British volunteer army rapidly growing in strength and the victory of Tannenberg (1914) averting crisis in the East, Falkenhayn selected as his target hard-pressed France,

[191] To take just one example of a deep unhappiness between theory and evidence, see Vasquez's criticism of realism in John Vasquez, "Coloring it Morgenthau: New Evidence for an Old Thesis on Quantitative International Politics," in John Vasquez (ed), *Classics of International Relations*, (Englewood Cliffs: Prentice Hall, 1990).

struggling mightily as it was against the much more populous Germany. "The strain on France," he wrote, "has reached breaking point." The best way forward, then, was to launch a limited offensive that would "compel the French to throw in every man they have. If they do so the forces of France will bleed to death."[192] By focusing on a point where the French would fight to hold regardless of the cost, Falkenhayn brought the truest measure of attrition to battle. In such a struggle, Germany's superiority in numbers would ensure that the French would crack first. Germany would succeed by 'bleeding the French white.'

The site chosen was the great French fortress of Verdun, exposed on three sides to 542 German heavy guns and a stock of 2.5 million shells to go along with them. The plan, labeled 'Operation Judgement,' was brutally simple:

> "The French, forced to fight in a crucial but narrowly constricted corner of the Western Front, would be compelled to feed reinforcements into a battle of attrition where the material circumstances so favoured the Germans that defeat was inevitable. If the French gave up the struggle, they would lose Verdun; if they persisted, they would lose their army."[193]

Under the relentless German pounding, the French almost did. Just three days into the battle, a French lieutenant of the 72nd division reported that: "The commanding officer and all company officers have been killed. My battalion is reduced to approximately 180 men (from 600). I have neither ammunition nor food. What am I to do?"[194] Even Émile Driant, the lieutenant colonel whose hastily constructed strongpoints in the Bois des Caures helped keep the Germans at bay in

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[192] Cited in John Keegan, *First World War*, p278.
[193] Keegan, *First World War*, p279. To this end, the French certainly behaved just as Falkenhayn anticipated. That the "original citadel was the handiwork of Vauban, Louis XIV's great military architect, the fortress has a patriotic aura that transcended its strategic significance." After Fort Douaumont fell, the lynchpin of the defensive system and seen by some as the strongest fort in the world, the call went out for a vast build-up in the Verdun sector. Nine months later, two-thirds of the entire French army had seen action at this part of the front. Roger Chickering, *Imperial Germany and the Great War, 1914-1918*, (Cambridge: Cambridge University Press, 2007 [2004]), p67.
[194] Cited from Keegan, *World War*, p281.

the battle's opening stages, was shot in the forehead while calmly preparing a withdrawal.[195]

But the Germans, opposed by an indomitable French fighting spirit suffered mightily as well. *Ils ne passeront pas!*—They shall not pass!—became a common rallying cry.[196] Desperate to carry the advance forward, the Germans pushed their horse-drawn gun teams further and further into the teeth of the enemy, suffering appalling casualties in the process. Some 7,000 horses are said to have been killed on a single day. German losses were so heavy that after the war the Crown Prince Wilhelm, commander of the Fifth Army, would record that "Verdun was the mill on the Meuse that ground to powder the hearts as well as the bodies of our soldiers."[197] As with any boiling cauldron, it scalded all who touched it.

For 302 days the battle raged. Falkenhayn had acquired the grinding, attritional struggle that he so desired. Back and forth the battle went, with the French rallying to each new challenge the Germans presented. The village of Vaux, for example, changed hands 13 times in March alone. Yet for all this fierce fighting, nothing was accomplished outside the death and mutilation of men, and the despoliation of the countryside. The lines hardly moved. Verdun did not fall. The French army did not crack. "Verdun had become a place of terror and death that could not yield victory."[198] But that futility did not stop the appeal of attrition. Incredibly, the British took away from Verdun the idea that victory could be achieved in a similar attack at the Somme (1916), if only the tables of material preponderance were reversed against Germany's favour. The assumption was that victory would arrive by no more than doubling and tripling Britain's artillery, attackers, and reserves. Haig boasted 1,500 pieces of artillery, one for every

[195] Meyer, *World Undone*, p371-375, 380-1. After the first day, after 80,000 shells fell on the wood—an area just 500 by 1,000 yards—Driant's battalions (originally some 1,300 men under his command) counted only seven lieutenants, every one of whom was wounded, and about a hundred troops still capable of fighting. Driant himself was killed the next day.
[196] This came from General Robert Neville's June 23 1916 order of the day. Cited in Cohen and Major, *Quotations*, p714.
[197] G.J. Meyer, *A World Undone: The Story of the Great War, 1914 to 1918*, (New York: Delta, 2006), p405.
[198] Keegan, *First World War*, p285.

seventeen yards of the eighteen miles of curving front along which the BEF would be attacking.[199] Breakthrough would be achieved through sheer chemical and physical mass. One officer told his men, "You will be able to go over the top with a walking stick, you will need rifles. When you get to Thiepval [a village to be taken on the first day] you will find the Germans all dead. Not even a rat will have survived."[200] Yet it was all utter folly, for the allure of preponderance did not hold true, and the struggle continued for more than 140 fruitless days. In the end, each side would endure over 600,000 casualties for a prize of six or seven miles of strategically worthless ground along a 30-mile front.[201] As at Verdun, attrition would not bring victory, only death and despair.

The lesson, then, is that attrition is the antithesis of strategy. It is a blind contention that 'numbers will win out,' yet then fails to suggest just how this is to be achieved. In policy terms, having a larger army, bigger battalions, or even just making sure the numbers match has long been a foremost concern of leaders, both military and political. Britain entered into an alliance with France prior to the First World War for precisely these numerical reasons.[202] Yet, as this study has demonstrated, faith in numbers is little insurance policy at all. As it was, the country was so mauled in the Great War that the splendour and glory of *Pax Britannica* was never to return. In theoretical terms, the results are far less vicious, but no less stark: the core hypothesis of all the variants of preponderance theory—that a superior weight in numbers is the ultimate guarantor of victory in battle—cannot be but considered conclusively dismissed.

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[199] Meyer, *World Undone*, p437.
[200] Cited in Meyer, *World Undone*, p438.
[201] Robert O'Connell, *Of Men and Arms*, (Oxford: Oxford University Press, 1990), p255.
[202] Good surveys of prewar diplomacy include M.B. Hayne, *The French Foreign Office and the Origins of the First World War, 1898-1914*, (Oxford: Oxford University Press, 1993; Zara S. Steiner, *Britain and the Origins of the First World War*, (New York: St. Martin's Press, 1977); Samuel R. Williamson, Jr., *The Politics of Grand Strategy: Britain and France Prepare for War, 1904-1914*, (Cambridge, Mass.: Harvard University Press, 1969); Paul Kennedy, *The Rise of Anglo-German Antagonism, 1860-1914*, (London: Allen & Unwin, 1980); and John H. Maurer, *The Outbreak of the First World War: Strategic Planning, Crisis Decision Making, and Deterrence Failure*, (Westport, Conn.: Praeger/Greenwood, 1995).

Chapter 3: Testing Technology Theory

The Mechanics of War

Assessing Technological Theories of Combat Victory

Advanced weaponry will "always overcome the inventions of the mind of generals of genius."[203]

Friedrich Engels

"Tools, or weapons, if only the right ones can be discovered, form 99 per cent of victory…Strategy, command, leadership, courage, discipline, supply, organization and all the moral and physical paraphernalia of war are nothing to a high superiority of weapons—at most they go to form the one per cent which makes the whole possible."[204]

J.F.C. Fuller

Abstract

The technology theory of victory is one that has grabbed hold of both generals and policymakers alike. The theory comes in two forms. First is that battlefield victory either goes to the strategic posture (offensive or defensive) favoured by the technological conditions of the day. This is known as 'systemic theory'. Second is the contention that the technologically superior of two belligerents will invariably emerge the winner, a variant known as 'dyadic theory'. Unfortunately, both variants have rarely been tested. Moreover, in the sparse instances where testing has taken place, it has never been against

[203] Friedrich Engels, *Anti-Duhring*, (New York: International Publishers, Inc, 1939), p185.
[204] January, 1919. Cited in Gray, *Another Bloody Century*, p99, fn #1.

> a series of cases with great historical breadth. This chapter has therefore collected data from 612 battles, spanning over 2,000 years, and contrasted their empirical details against the central hypotheses of technology theory. Unfortunately for the theory, there is neither is any suggestion of a consistent favouring of one posture or another—a necessary precondition to technological determinism—nor an overwhelming advantage that accrues to the army with more capable technology.

As the epigram suggests, technological determinism has been advanced by some of the most esteemed thinkers in the history of political and military science. The idea that "war is completely permeated by technology and governed by it"[205] holds incredible allure. Such attraction is felt both inside the halls of the academy and within policymaking circles. Never was this more the case than in the months that followed the September 11, 2001 collapse of the Twin Towers. In the days that followed it became quickly apparent that these horrific attacks were orchestrated by an al-Qaeda leadership that enjoyed sanctuary in Afghanistan. In response, President Bush issued an ultimatum to their hosts: "The Taliban must act, and act immediately," he announced in a televised address to Congress. "They will hand over the terrorists or they will share their fate."[206] The following day, September 21, he approved plans for air strikes and attacks on al-Qaeda and Taliban targets by Special Operations forces. These would be conducted in partnership with "the troops of sympathetic (or perhaps opportunistic) Afghan warlords," with a small-scale US ground invasion to follow.[207] On October 7, after Mullah Omar and his Taliban cabinet failed to hand over Osama bin Laden, the al-Qaeda chief, the invasion began. The violence that followed was as swift as it was ferocious. America's Northern

[205] Martin Van Creveld, *Technology and War*, (New York: The Free Press, 1991), p1.
[206] Geoffrey Parker (ed), *Cambridge History of War*, (Cambridge University Press, 2005), p406.
[207] Parker, *History*, p406.

Alliance allies were stunned to witness laser designation and radio communication being followed by a deep rumbling, billowing clouds of dust, and the near-instantaneous destruction of Taliban positions.[208] In all, 6,500 strike missions—incorporating some of the most destructive conventional weaponry ever devised—were leveled at an enemy armed with only the most rudimentary of technology. Although bin Laden was able to flee, the Taliban regime collapsed against such potent military power.

The technologists began crowing about the surprising ease of this achievement even before the exiled politician and interim head of state, Hamid Karzai, returned to Kabul. The unfathomable discrepancy in technology between the US and the Taliban, the thinking went, made possible a victory that took under two months and less than 20 coalition dead. "The genuinely novel combination in Afghanistan in 2001-2002 of special operations forces (SOF), cued by unmanned aerial vehicles (UAV), communicating via space systems to strike aircraft, was hailed by excited journalists as if they had witnessed the Second Coming."[209] Writers such as Bruce Berkowitz suggested that the "the Information Revolution has fundamentally changed the nature of combat. To win wars today, you must first win the information war."[210] Nor were these commentators alone; many policymakers became enamoured with such notions as well. By 2002, then-Deputy Secretary of Defense Paul Wolfowitz admitted that "some people in the Rumsfeld circle believe that 'air power is now so accurate that you don't need armies.'"[211] Afghanistan was seen a vindication of technology theory, and as evidence that it is possible–if

[208] The Taliban's tendency to emplace forces without cover and on exposed ridges made it a good deal easier for the encircling B-52 and A-10 ground-attack aircraft. See Michael E. O'Hanlon, 'A Flawed Masterpiece,' in Robert J. Art and Kenneth N. Waltz, *The Use of Force*, (Lanham: Rowman & Littlefield, 2009).
[209] Gray, *Another Bloody Century*, p101.
[210] Bruce Berkowitz, *The New Face of War: How War Will Be Fought in the 21st Century*, (New York: Free Press, 2003), pxi.
[211] Peter J. Boyer, "A Different War: Is the Army Becoming Irrelevant?", *New Yorker*, 78.17 (July 1, 2002), p54-67. The article quotes an interview conducted several weeks before. See "Deputy Secretary Wolfowitz Interview with the *New Yorker*," Tuesday, June 18, 2002. Available at www.defenselink.mil.

not especially rewarding—to fight 'light' and with as small a footprint as possible, so long as one goes to battle with an appropriate superiority in technology.

It soon became apparent, however, that the effects of technology were not as certain as they once seemed. Particularly problematic was how the 2003 Iraq invasion, conducted by the most technologically advanced army ever assembled, quickly descended into chaos. Despite the yawing technological gap between the invaders and insurgents, the 130,000-strong American invasion force[212] soon found themselves stretched almost to the breaking point. The task of occupying a country roughly the size of California and with 25 million inhabitants was simply too much for an army of this size. A similar dynamic was soon witnessed in Afghanistan as well, where the stunning success of the original invasion was replaced by a bloody and protracted uprising, with not enough garrison troops to go around.

In retrospect, the rapid deterioration of America's strategic situation in both theatres should not have come as a surprise. The path to civil was presaged by a series of ominous warning signs. Most telling was that regardless of their rapid defeat, the Taliban consistently demonstrated an incredible aptitude for learning. In particular, a combination of battlefield experience and the arrival of better-trained foreign fighters led to dramatic tactical improvements that mitigated technology's combat impact in a very short period of time. Just weeks after the US invasion began, the defenders went from ignoring even elementary sources of cover to an adept use of natural terrain. Foliage and buildings in particular degrade sensors, and the Taliban began exploiting this with ever-increasing skill. This made it more and more difficult for US forces to find targets, no matter how advanced their gadgetry. By November, Taliban positions were going undetected regardless of how much reconnaissance was put towards their

[212] This was a remarkably low number, given that the 1991 coalition stood 500,000 strong—and it did not even enter Baghdad. Thus even when the 45,000 British and 2,000 Australian soldiers are added to the 2003 total, the invasion force comes off as particularly light.

discovery.[213]

So what, then, is the effect of technology? Obviously weapons play a crucial role on the battlefield, but do they determine winning? Are they the most crucial determinant of military capability? The Afghanistan and Iraq cases certainly give pause for thought. We cannot be certain, however, whether or not these fears are well-founded until the literature's dearth of empirical evaluation is overcome. This chapter will therefore review the theory's main precepts, and then subject the central hypotheses to empirical test.

3.1 Literature Review: Technology Theory

Second in popularity to the preponderance theory of victory[214] is that which deals with technology.[215] Here the concern is with either the aggregate stock of military technology between two rivals (the 'dyadic technology balance'), or the system-wide military-technology condition known as the 'offence-defence balance.'[216] In both instances, the balance can be seen as either a purely technological condition (that is, simply a matter of engineering), or as the product of a confluence of technology *and* the training and organizational doctrines[217] created and implemented to use these weapons. We will discuss this distinction in greater length below, but at the heart of the theory is the argument that technology is the chief determinant of

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[213] Stephen Biddle, "", in John Baylis, James J. Wirtz, Eliot A. Cohen, Colin S. Gray, *Strategy in the Contemporary World: an Introduction to Strategic Studies*, (Oxford, 2010), p268-70.

[214] Some even go so far as to declare that offence-defence theory is "the most powerful and useful realist theory on the causes of war." Stephen Van Evera, *The Causes of War*, (Ithaca, NY.: Cornell University Press, 1999), p117.

[215] For an interesting discussion of technology and its history more generally, see Cardwell, *Wheels, Clocks and Rockets: A History of Technology*. See also the *Oxford History of Technology*; Forbes, Klemm, Usher, Habbakuk, Landes, Musson, Robinson, Rosenberg (see Cardwell p5), Whitehead and Needham; cited in Cardwell, *Clocks*, p18.

[216] An excellent bibliography of offence-defence theory can be found in Michael Brown *et al*, *Offense, Defense, and War: An International Security Reader*, (Cambridge, MA: MIT University Press, 2004), p439-444.

[217] John A. Alic defines doctrine as that which "prescribes and training instills warfighting practices." It "refers to a military's codified prescriptions of how to fight—rooted in experience and adjusted based on lessons from large-scale conflicts." (p15). Doctrine is used to "provide a foundation for the exercise of discretion in combat. Doctrine and discipline instilled through peacetime training serve as antidotes to the confusion and fear of battle, bulwarks against panic and flight. At the same time, doctrine sometimes can become part of a belief system that stifles fresh thinking and inhibits innovation." (p16) Alic, *Trillions for Military Technology*, (New York: Palgrave Macmillan, 2007).

battlefield success. In the theory's dyadic form, technological supremacy is seen as likely to ensure victory over a rival. In this way the largely agrarian Taliban are anticipated to consistently lose to their better-equipped NATO rivals. Even more popular, however, is the systemic technology or 'offence-defence' variant. This is the argument that the offence-defence balance serves to make it either "easier" to conquer territory or to defend it, regardless of the technology holdings between two belligerents.[218] The promise of technology[219] is therefore to favour those who adopt an aggressive strategic posture—including the deployment and use of standing armies and stocks of offensive weapons—when offence reigns supreme, and those who assume defensive strategies when the balance sits in favour of the defender.

This assumption is crucial, as the systemic version's basic prediction is that international events will reflect the technological conditions of the day. When offence dominates "the security dilemma becomes more severe, arms races become more intense, and war becomes more likely."[220] The writing writings of early eminent military thinkers such as Sun Tzu, Jean-Jacques Rousseau, Carl von Clausewitz, and Antoine-Henri Jomini allude to this, at least in a

[218] As originally described by Robert Jervis, "Cooperation under the Security Dilemma," *World Politics*, (January, 1978), 187-194, 199-206. For an overview of the theory, see Sean Lynn-Jones, "Offense-Defense Theory and Its Critics," *Security Studies*, (Summer, 1995), 660-91; and Michael E. Brown *et al* (eds), *Offense, Defense, and War*, (Cambridge: MIT Press, 2004). For an extensive review of the historical record, see Stephen Van Evera, "Offense, Defense, and the Causes of War," *International Security*, Vol. 22, No. 4 (Spring 1998), p5-43, as well as his "The Cult of the Offensive and the Origins of the First World War," *International Security*, Vol. 9, No. 1 (Summer 1984), p58-107, and *The Causes of War*, (Ithaca, NY.: Cornell University Press, 1999), esp chpt 6. Van Evera argues that states are seldom as insecure as they believe they are. Great powers are more likely to imagine insecurity, pre-emptively attack and then lose, rather than suffer from an unprovoked invasion. See also Charles Glaser and Chaim Kaufman, "What is the offense-defense balance and can we measure it?" *International Security*, (Spring 1998); Jack Snyder, *The Ideology of the Offensive*, (Ithaca, NY.: Cornell University Press, 1984); and Jack Snyder, "Perceptions of the Security Dilemma in 1914," in Robert Jervis, Richard Ned Lebow, and Janice Gross Stein (eds), *Psychology and Deterrence*, (Baltimore: Johns Hopkins University Press, 1985), p153-179.

[219] For a brief, readable survey of the attractiveness of technology, and the efforts undertaken to uncover war-winning devices, see Ernest Volkman, *Science Goes to War: The Search for the Ultimate Weapon, from Greek Fire to Star Wars*, (New York: John Wiley & Sons, 2002). One of the core lessons of the books is that science got into the "death business" some three thousand years ago, and never got out of it. (p10-11).

[220] Charles Glaser and Chaim Kaufman, "offense-defense balance." The authors make a compelling effort to define and measure the concept.

nascent form.[221] The great Clausewitz, for example, argued that "if the attack were the stronger form…no one would want to do anything but attack."[222] This was certainly witnessed in the First World War, where arms racing ran rampant, escalating tension with a succession of international crises.[223] Given that the leaders of the day were convinced that technology favoured the attacker, this dilemma eventually deteriorated into systemic war.[224] On the other hand, when defensive weapons and strategies are dominant,[225] conditions are held to be much more stable.[226] In this regard, the theory is optimistic; when defence has the edge, conflict is

[221] Keir Lieber, *War and the Engineers*, p7. For work on the ideas of offensive and defensive balances in Sun Tzu and Jomini, see Stephen Duane Biddle, "The Determinants of Offensiveness and Defensiveness in Conventional Land War," (Phd. dissertation, Harvard University, 1992), p22-30. Regarding Rousseau, see Stanley Hoffmann, *The State of War*, (New York: Frederick A. Praeger, 1965), p74-82; and Robert E. Osgood and Robert C. Tucker, *Force, Order, and Justice*, (Baltimore: Johns Hopkins University Press, 1967), p12. Lieber, *Engineers* p184 fn#16 also notes that more recent scholars (though prior to the truly foundational works of offence-defence theory, written to explain the strategic stability brought on by nuclear weapons in the 1970s and 1980s) include J.F.C. Fuller, "What Is an Aggressive Weapon?" *English Review*, 54 (June 1932), p601-5; B.H. Liddell Hart, "Aggression and the Problem of Weapons," *English Review* 55 (July 1932), p71-78, espec 72-73; B.H. Liddell Hart, *The Memoirs of Captain Liddell Hart*, (London: Cassell & Co., 1965), p186; Marion William Boggs, *Attempts to Define and Limit 'Aggressive' Armament in Diplomacy and Strategy*, (Columbia: University of Missouri Studies, vol 16, no. 1, 1941); Quincy Wright, *A Study of War*, (Chicago: University of Chicago Press, 1965), p807-10; 1518-21 [1st ed 1942]; Malcolm W. Hoag, "On Stability in Deterrent Races," RAND, 1961; and Thomas C. Schellling, *Arms and Influence* (New Haven: Yale University Press, 1966), p224-25; 234-35.

[222] Carl von Clausewitz, *On War*, Michael Howard and Peter Paret (ed and trans), (Princeton: Princeton University Press, 1976), p217-18; 359.

[223] Of these the most important were the 1905 (1st) Moroccan 'Tangier' Crisis, the 1911 (2nd) Moroccan 'Agadir' Crisis, and the 1st (1912) and 2nd (1913) Balkan Wars.

[224] Van Evera, *Causes*, details the WWI example and compares the theory to European, US, and ancient Chinese history, 171, 180, 234. It should be noted that more than offensive *technology* matters to this balance. Prevailing strategy and tactics can also determine the relative dominance of offence, thus tilting the deliberations of war to a more aggressive nature. See Jack Snyder "The Cult of the Offensive in 1914," in Art and Waltz, eds, *The Use of Force*, (Lanham: Rowman & Littlefield, 1999), 113-29. For example, "Military technology should have made the European strategic balance in July 1914 a model of stability, but offensive military strategies defied those technological realities, trapping European statesmen in a war-causing spiral of insecurity and instability." (Ibid., 113). The Boer and Russo-Japanese wars immediately prior demonstrated that the technological advantage was squarely on the side of the defender. (Ibid.) It is therefore imperative to examine the offence-defence balance in light of the totality of the military instrument (as "an amalgam of technology, doctrine, training, and organization"), Ashley Tellis, Janice Bially, Christopher Layne, Melissa McPherson, and Jerry Sollinger, *Measuring National Power in the Post-Industrial Age*, (Santa Monica: RAND, 2000), p41.

[225] Weapons can obviously be employed in both offensive and defensive situations, but are relatively more effective in one posture than the other. For example, fortresses and machine guns are better suited to defence, while artillery and armoured vehicles are more effective in offensive operations. Military strategies share similar characteristics.

[226] Glaser and Kaufmann, "offense-defense balance."

likely to be resolved without resorting to arms.[227] As Clausewitz, observed, "the greater strength of the defensive [might] tame the elemental fury of war."

Much of this speaks to the matter of war initiation. Offence-defence theorists commonly contend that technological conditions—along with their associated doctrines and preparations—make the chance of war more or less likely. Yet these arguments are implicitly about more than just predictions regarding the frequency of war. Indeed, the proponents of technology theory are united by the underlying argument that technological conditions shape military *outcomes*. Technology theory is, after all, ultimately a story about the determinants of who wins and who loses. The prospects for the outbreak of war are no more than a reflection of the prospects for victory for a given strategic posture. When technologists are optimistic that peace will hold, the implicit assumption is that defensively-oriented forces are more capable than offensive ones. Under such conditions there is little incentive to attack. This is not the case, however, when armies on the attack are likely to prevail over their opponents. Here technologists are much more pessimistic about the prospects for peace. The lesson is that the broader issue of system stability is simply a second-order effect, felt as a consequence of technology's impact on battlefield outcomes. Although the existing literature usually does not make this association explicit, battlefield performance lies at the heart of all technologists' claims. The offence-defence war initiation literature is simply an extension of the central technologist claim: that battles will be won by postures favoured under current technological conditions.

Regardless of these forays into the art of conflict prediction, it is the connection between technology and battlefield success that lies at the heart of the technology literature. The

[227] Ibid. This is reinforced by Schweller's observation that at least some states are likely to be happy with the balance of power and thus have no incentive to change it. Randall Schweller, "Neorealism's Status Quo Bias: What Security Dilemma?," *Security Studies* 5, No. 3 (Spring 1996, special issue on "Realism: Restatements and Renewal," ed. Benjamin Frankel), p98-101.

similarity of post-Cold War RMA arguments and Fuller's interwar musings, for example, are pronounced. Spurred on by his personal experience as chief general staff officer of the British Tanks Corps in World War I, Fuller concluded that "the highest form of machinery must win, because it saves time and time is the controlling factor in war."[228] RMA scholars are similarly enamored with what technology can do, viewing information technologies and precision-guided munitions as excitedly as Fuller did the tank. While the form technology takes may change over time, the enthusiasm technologists hold for such instruments does not.

This is not to say that the technology school enjoys unanimity in thought. On the contrary, the literature is divided over two core issues. The first relates to how strictly materialist the concept of 'technology' should be. Does the technological balance between offence and defence rely on purely technology matters? Or should an encapsulation of the offence-defence balance incorporate military doctrines and even leaders' perceptions as well? The second debate is, as we saw above, whether the technological balance is dyadic or systemic in its effects. Does the relative endowment of technology operate purely between two belligerents? Or does it affect all actors in the international system equally? Given the complexity of technology theory—and with the differences between variants often left ill-defined—it is worth considering each in turn.

What Constitutes the 'Balance'?

The first matter of contention regards precisely what the offence-defence balance consists of.[229] Some theorists favour a narrow, "core" conception, while others advocate a more inclusive

[228] Fuller, *Memoirs*, p922.
[229] For efforts to measure the technological 'balance', see Glaser and Kaufmann, "offence-defence", p44-82; Stacie Goddard, "Correspondence: Taking Offense at Offense-Defense Theory," *International Security*, Vol. 23, No. 3 (Winter 1998/1999), p189-195; Stephen Van Evera, "Correspondence: Taking Offense at Offense-Defense Theory," *International Security*, Vol. 23, No. 3 (Winter 1998/1999), p195-200; and Charles L. Glaser and Chaim Kaufmann, "Correspondence: Taking Offense at Offense-Defense Theory," *International Security*, Vol. 23, No. 3 (Winter 1998/1999), p200-206.

or "broad" version.[230] The former primarily concerns itself with military technology alone.[231] What matters most are the dominant weapons systems of the day and whether or not their potency—either alone or in combination with other weapons systems[232]— favours an offensive or defensive strategic posture.[233] The balance is therefore a reflection of the military technological condition in its totality. It is an aggregation of individual weapons systems working in concert with other weapons, resulting in a net effect. Indeed, it "is not individual weapons *per se* but the general technological characteristics underlying a pool of weapons systems at any given time."[234] The chief concern of core theory is thus how this *overall* technological condition gives added military effectiveness to either attackers or to defenders.

In contrast to this mechanistic approach, the broad perspective attempts to incorporate not only technology, but other variables as well. These include geography,[235] the "cumulativity of resources"[236] (how easy it is to harvest the resources of freshly conquered territories),[237] nationalism,[238] regime popularity,[239] alliance behaviour,[240] force size,[241] and military doctrine,

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[230] Lieber, *Engineers*, p28-34. Lieber eventually sides with the core version. (p33-4) See also Lynn-Jones, "Offense-Defense Theory and Its Critics," p667.
[231] Proponents of this view include George Quester, Robert Jervis, and Sean Lynn-Jones. "Although Jervis cites technology and geography as the two main factors that determine whether offense or defense has the advantage, technology appears more significant for understanding the severity of the security dilemma." Lieber, *Engineers*, p192 fn#10, speaking of Jervis, "Cooperation," p194-96.
[232] "Individual weapons systems almost invariably combine technologies that can be labeled offensive or defensive." Lynn-Jones, "Offense-Defense Theory and Its Critics," p675.
[233] The only exception to this focus are the nonmilitary technological advances which facilitate and improve the production, improvement, and deployment of weapons systems.
[234] Lieber, *Engineers*, p35.
[235] For example, the balance in favour of Switzerland's defence, given the high Alps, as opposed to those nations along the vast Eurasian plain. For further geographic arguments, see Jervis, "Cooperation," p183-185, 194-96; Van Evera, *Causes of War*, p163; and Glaser and Kaufmann, "What Is", p64-66.
[236] Lieber, *Engineers*, p30.
[237] Ted Hopf, "Polarity, the Offense-Defense Balance, and War," *American Political Science Review*, 85 (June 1991), p477-78; Lynn-Jones, "Offense-Defense Theory and Its Critics," p669; and Glaser and Kaufmann, "What Is," p67-8.
[238] Glaser and Kaufmann, "What Is", p66-67, 67n68; and Jervis, "Cooperation," p195.
[239] Van Evera, *Causes of War*, p163-4.
[240] Van Evera, *Causes of War*, p164-66; Hopf, "Polarity," p477-78;
[241] "once armies grow so big they can cover an entire frontier…their size aids the defense because offensive outflanking maneuvers against them become impossible." Van Evera, *Causes of War*, p161n162. In much the same

posture, and deployment.[242] Each factor is seen by broad theorists as being able to amplify or diminish underlying technological conditions. Even the most sophisticated tanks make poor progress in mountain and bog. Nationalism can inure young infantry to heavy losses. Army infantry manuals can stress either the bayonet charge or shovel entrenchment. Each factor must be incorporated when determining the overall offence/defence balance, for how easy it will be to attack or defend a position will depend on a combination of some or all of these non-technological considerations.

Most crucial to broad technology theory, however, is the matter of perceptions. Military performance is seen here as ultimately resting on how accurately underlying technological conditions are perceived, then translated into military policy. Crucially, militaries and foreign policy establishments are prone to pathologies that undercut a proper understanding of the *actual* offence-defence balance. Bureaucratic incentives in particular often lead to the promotion of offensive postures, even when the technology of the day is best suited to the opposite. It is, after all, in the military's rent-seeking self-interest to promote its usefulness at all turns.[243] This tendency is made even worse by the fact that it is not easy to determine what weapons and

way, size can benefit a defensive-minded belligerent, since the achievement of a completely decapitating nuclear first strike becomes harder as the target force size increases. Glaser and Kaufmann, "offence-defence," p66.

[242] Here the argument is that military doctrines, "especially those concerning the use of a new technological innovation, can change the balance. Offense became easier, for example, when the blitzkrieg doctrine made motorized armor a more effective instrument in the attack." Lieber, *Engineers*, p32. Speaking of Van Evera, *Causes of War*, who himself added that military posture and force deployment matter as well. "Stalin eased attack for both himself and Hitler during 1939-41 by moving most of the Red Army out of strong defensive positions on Soviet territory and forward into newly seized territories in Poland, Bessarabia, Finland, and the Baltic states. This left Soviet forces better positioned to attack Germany, and far easier for Germany to attack, as the early success of Hitler's 1941 invasion revealed." (Van Evera, *Causes of War,* p162). To this, though, Glaser and Kaufmann disagree. "When states act optimally, doctrine and deployments merely reflect the balance; they are outputs of the optimization process, given the constraints imposed by the offense-defense balance and the distribution of resources. Suboptimal choices will influence a state's deployed capabilities but not the offense-defense balance." Glaser and Kaufmann, "offence-defence," p41.

[243] Posen, *Sources of Military Doctrine*, p58-9.

strategies do and do not work in war without actually fighting one.[244] Even when battle is underway, it is difficult to translate both ideas and practical technology into useful military applications. The US Army, for example, was halting and indecisive in exploiting airpower in the Great War. Lacking an accepted doctrine governing the employment of aircraft, America's air arm stumbled on the battlefield. No matter how rapid the technological progress in areas such as airframe payload and speed, the leadership struggled mightily to find ways to put their planes to good use.[245] Proper perception of technological conditions can be an extremely difficult thing to get right.

The resilience of such errors matters greatly, for the pathologies and misperceptions that surround the offence/defence balance can have a devastating impact on battlefield performance. More specifically, when policymakers choose a strategic posture that does not fit the times, calamity ensues. Jervis, for example, has argued that if the great powers had correctly recognized that the military balance was firmly in favour of the defensive in 1914, their armies would have rushed for trenches that fateful summer, rather than striking out on a fruitless march against their rivals.[246] This was, in fact, essentially what happened at sea, given that the great navies of the day better understood how much naval technology favoured defensive action.[247] Rather than rush towards a decisive battle, the Grand and High Seas fleets settled immediately into a defensive posture, readying themselves for the long struggle that they were sure was to

[244] Howard has likened this the difficulty inherent in peaceful military innovation as that a surgeon who is unable to operate. Cited in Knox and Murray, *Dynamics*, p14.
[245] I.B. Holley, *Ideas and Weapons*, cited in Alic, *Trillions*, p20 fn #9. Fn #10 for the British tank experience, where, in contrast, once Britain was able to field tanks in large enough numbers, the army's understanding of effective tank use advanced rather quickly.
[246] Jervis, 1978.
[247] The high seas fleets of both German and Great Britain would go on to predominantly stick to playing cat and mouse as the war progressed. See, for example, Richard Hough, *The Great War at Sea, 1914-1918*, (Oxford: Oxford University Press, 1983); and Paul G. Halpern, *A Naval History of World War I*, (Annapolis, Md.: Naval Institute Press, 1994).

come.[248] In contrast, the murderous futility of Verdun (1916), the Somme (1916), and Passchendaele (1917) demonstrates how ill-conceived faith in offensive action led to relentless attack and counter-attack, all to fruitless result. In each case, roughly a million casualties were expended in exchange for a few barren miles of strategically worthless terrain. What the navies of August 1914 got right the armies held in tragic error. It is therefore the *perception* of technology that serves as the ultimate causal variable in broad theory, not technology itself. Should a policymaker misperceive the underlying technological reality, armies will be left ill-equipped, lacking appropriate doctrine, and ordered to a strategic posture that is incongruous with the material conditions in which they are fighting. Defeat is therefore likely to follow.

So What 'Balance' Is It?

Despite its attractiveness to policymakers and press, technology theory faces a series of ambiguities that obfuscate its core precepts. As we have just seen, foremost amongst these complications is the battle between the theory's 'core' and 'broad' versions. This distinction indicates a high degree of uncertainty regarding precisely what the theory's ultimate causal variable is. Is it technology itself? Or is it the ability of organizations to accurately perceive and effectively embrace said technology? In many ways, moving beyond the consideration of technology alone opens up the theoretical equivalent of Pandora's box, adding a confusing and disparate array of variables to the causal equation. The additional variables serve only to obfuscate and undermine conceptual clarity.

Put another way, the 'broader' technology theory gets, the less important the actual underlying technological condition becomes. After all, broad theories do not hold material

[248] Fascinatingly, the decisive moment of the single titanic naval engagement between the Grand and High Seas Fleets at Jutland in 1916 was characterized by the main British fleet turning *away* from the fleeing German fleet after a defensive screen of torpedoes was launched. See Geoffrey Bennett, *The Battle of Jutland*, (London: David & Charles, 1972); and N. Campbell, *Jutland: An Analysis of the Fighting*, (London, 1986).

conditions as the causal variable *per se*, but instead delve into the matters of training, tactics, and organizational structure. The concept has thus become a catch-all for a variety of variables, of which technology itself plays only a subsidiary role.[249] The result is a "grab bag of variables employed in a post hoc descriptive enterprise for each specific and unique case."[250] According to broad theories, technology can change all it wants, but what matters most is how this force is mitigated and amplified through corresponding shifts in perceptions and doctrine. The effect is to downplay the role of technology substantially. For example, a systemic technologist would not look only at the development of a more destructive artillery shell (the underlying technology), but also the doctrinal responses to it, such as the greater diffusion of troops on the battlefield. In this way, technology is no more than an inert, intervening variable between doctrine and battle outcomes. The broad theory of technology is therefore improperly labeled, for it is not about technology at all.

With this in mind, discussions of technology theory are best served by cleaving to the 'core' version, for this is the only iteration that is actually concerned with technology.[251] This paper will therefore stick to the theory's *technological* component, and leave considerations of the role of tactics and strategic orientation on military success for later work.

Dyadic vs Systemic Theory

The second debate within technology theory concerns the form through which technology's effects are felt. As outlined by Biddle, there are two chief theories regarding how

[249] See Van Evera, "Offense, Defense, and the Causes of War." Also James W. Davis, Jr., "Correspondence: Taking Offense at Offense-Defense Theory," *International Security*, Vol. 23, No. 3 (Winter 1998/99), p179-182 and Bernard I. Finel, ibid, p182-189.
[250] Lieber, *Engineers*, p33.
[251] It may prove entirely correct that technology is peripheral to the determination of battlefield victory and defeat, and that other variables related to doctrine are much more central. These variables must, however, be tested on their own accord.

technology affects battlefield outcomes.[252] The first suggests technology operates in a 'systemic' fashion.[253] By this, the argument is that the effects of technological balance are felt system-wide. Thus when either weapons of attack or defence are the most dominant, *all* actors will feel the effects of this balance equally. For example, systemic theorists argue that when machine guns and barbed wire dominated the battlefield in the early 20thC, defence reigned supreme, no matter which participant was involved. The technological conditions of the day ensured that defence would be rewarded and offence brutally punished, regardless of the technological variance between belligerents. "For systemic theorists, technology's main effect is thus not to strengthen A relative to state B—it is to strengthen *attackers* over *defenders* (or vice versa) regardless of who attacks and who defends."[254] In this light, with the defensive posture so potent in 1914, it is unsurprisingly that the highly aggressive opening moves of the Germans, French, Austrians, and Russians that fateful August all failed so miserably.[255]

It was precisely this debacle that lead to considerations of the systemic technology balance. At the forefront of such thinking was Great War veteran and British intellectual, J.F.C. Fuller. "Some weapons," he argued, "undoubtedly possess a higher offensive power than others."[256] A tank's mobility, armour, and ammunition supply, for example, "enables an army to

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[252] Stephen Biddle, *Military Power: Explaining Victory and Defeat in Modern Battle*, (Princeton: Princeton University Press, 2004), p15-17.
[253] Robert Jervis, "Cooperation under the Security Dilemma," *World Politics*, 30, 2 (January 1978), p167-214, George Quester, *Offense and Defense in the International System*, (New York: Wiley, 1977); Jack Snyder, *The Ideology of the Offensive*, (Ithaca: Cornell University Press, 1984), p9-22; Charles Glaser Chaim Kaufmann, "What is the offense-defense balance and can we measure it?," *International Security*, (Spring 1998), p44-82; Sean Lynn Jones, "Offense-Defense Theory and Its Critics," *Security Studies*, 4,4 (Summer 1995), p660-91; Stephen Van Evera, *Causes of War*, (Ithaca: Cornell University Press, 1999); Stephen Biddle, "Rebuilding the Foundations of Offense Defense Theory," *Journal of Politics*, 63,3 (August 2001).
[254] Biddle, *Military Power*, p15.
[255] See, for example, Barbara Tuchman, *The Guns of August*, (New York: Macmillan, 1962); Lyn MacDonald, *1914* (New York: Atheneum, 1988); Michael Keegan, *The Opening Moves: August 1914*, (New York: Ballantine, 1971); and Alan Clark, *Suicide of the Empires: The Battles of the Eastern Front, 1914-1918*, (New York: American Heritage Press, 1971).
[256] J.F.C. Fuller, "What Is an Aggressive Weapon?," *English Review*, (June 1932), p601-5, at 601. Cited in Lieber, *Engineers*, p37.

obtain greater effect from its weapons, in a given time and with less loss to itself than an army which relies upon muscular energy."[257] From this Fuller's strong advocacy of mechanized warfare followed. If you want to win, build tanks. Likewise, Fuller's contemporary B.H. Liddell Hart contended that there are kinds of "weapons which inherently favour[] the offensive."[258] Given the subtle promise offered by Britain's World War I tank experience, it is unsurprising that he too became an advocate of mechanized warfare.[259] Systemic theory was thus a response to the bloody stalemate of the First World War and a prescription should the European continent descend into a Second.

While the systemic view enjoys status as "political science's chief understanding of technology's role in international security,"[260] there is an additional, slightly competing claim. Another version of technology theory holds that the effects of the military balance are 'dyadic.' This means that technology favours a particular belligerent regardless if they are attacking or defending. What matters instead is relative technological supremacy. Should belligerent A enjoy superior technology to belligerent B, A will prevail regardless of the systemic balance. More formally, "Whereas systemic technology theorists see technology as favoring attack or defense across the international system, dyadic theorists see its chief effect as favoring individual

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[257] J.F.C. Fuller, *Memoirs of an Unconventional Soldier*, (London: I. Nicholson and Watson, 1936), excerpted in Gérard Chaliand, *The Art of War in World History*, (Berkeley: University of California Press, 1994), p922.
[258] B.H. Liddell Hart, "Aggression and the Problem of Weapons," *English Review*, 55 (July 1932), p71-78, espec p72-73. Cited in Lieber, *Engineers*, p37. See also Liddell Hart, *The Memoirs of Captain Liddell Hart*, (London: Cassell & Co., 1965), p186.
[259] On mechanization, the Liddell Hart relied heavily on the elder Fuller. In fact, "so much did the younger man lift—not to say, steal—from the works of the older one that their friendship almost went to the dogs." Martin Van Creveld, *The Art of War*, (London: Cassell, 2002), p179. The looming Second World War, however, kept Liddell Hart from combining this interest in technology with his 'strategy of indirect approach.' Instead, the prospect of repeating the slaughter of World War I led him to retreat from such a proposition and suggest Britain stick to blockades and airpower in any potential conflict with Germany. p183.
[260] Biddle, *Military Power*, p15. Even the constructivist Alexander Wendt appears to be a proponent of offence-defence theory, as he writes "When defensive technology has a significant (and known) advantage, or when offensive technology is dominant but unusable, as with nuclear weapons under Mutual Assured Destruction, then states are constrained from going to war and thus, ironically, may be willing to trust each other enough to take on a collective identity." Alexander Wendt, *Social Theory of International Politics*, (New York: Cambridge University Press, 1999), p358.

states over others, depending on their particular holdings."[261] For example, the combination of the three-masted caravel and cannon allowed the West European powers to traverse the world's oceans throughout the age of imperialism with virtual impunity.[262] When facing conditions of such dramatic technological inferiority, even the great states of Mughal India, Ming China, and Tokugawa Japan could do little to rid their home waters of the tirelessly meddlesome and territorially ambitious Europeans, no matter the systemic balance. The marauders' technology was simply too strong.

Dyadic technology theory has been particularly welcomed inside the halls of Western policymakers.[263] Faith in the utility of dyadic technological superiority, for example, drove US defence planning throughout the Cold War.[264] Unable to compete with the Soviet Union in sheer numbers, the Pentagon aimed to deploy technologically superior forces capable of 'offsetting' the inequality in numbers. Central to this conviction that an outnumbered NATO could hold off a potential Soviet thrust through Central Europe was that superior Western technology would ensure loss exchange ratios sufficiently favourable to offset the disparity. Soviet numbers would be mitigated with Western ingenuity. Moreover, the theory's hold on planning and procurement survived the fall of the Cold War quite handily. Indeed, the dream of a Revolution in Military Affairs (RMA) 'transformation' ruled the thinking of many scholars throughout the 1990s and 2000s.[265] In America, dyadic technologists were particularly boastful, claiming that

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[261] Biddle, *Military Power*, p16.
[262] At least against the Asian, African, and American dyads that were vastly technologically inferior. Carlo Cipolla, *Guns and Sails: Technological Innovation and the Early Phases of European Expansion, 1400-1700*, (Random House, 1965).
[263] Lieber, *Engineers*, p12-15 discusses at length how offence-defence theory pervades modern security debates, running from the Land Mines Convention of 1997, to the Missile Technology Control Regime, to America's National Missile Defense program, and to the modern preoccupation with terrorism.
[264] Harold Brown, *Thinking about National Security*, (Boulder: Westview, 1983), p225-33; and William Perry, "Defense Technology," in Asa Clark and John Lilley (eds), *Defense Technology*, (New York: Praeger, 1989).
[265] Alvin and Heidi Toffler, *War and Anti-War: Survival at the Dawn of the 21st Century*, (Boston: Little, Brown, 1993) spoke of the transition from "Brute Force to Brain Force." See also Paul Bracken, "The Military after Next,"

advancements in the IT sector had placed the US at an even greater dyadic advantage. "The technology that is available to the US military today and now in development," argued William Owens, "can revolutionize the way we conduct military operations."[266] We turn now to an evaluation of whether such a claim is grounded in historical fact.

3.2 Research Design

Operationalizing Technology Theory: Concepts, Hypotheses, and Validity

Transforming the logic of technology theory into testable hypotheses is a complicated matter. As we have seen, the best way to assess the causal importance of technology itself is to strip away variables outside of technology and leave only the underlying, materialist core. More arduous, however, is the task of actually measuring the variables involved in even this streamlined incarnation. There are, after all, many different technologies involved in a given war, some which will favour attackers and others, defenders. Most challenging of all, it can be difficult to determine whether a weapon is offensive or defensive in nature.[267] Tanks, for

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The Washington Quarterly, 16,4 (Autumn 1993), p157-74; Gordon Sullivan and Anthony Coralles, *The Army in the Information Age*, (Carlisle: U.S. Army War College, March 1995); Admiral William A. Owens, Jr., "The American Revolution in Military Affairs," *Joint Force Quarterly*, (Winter 1995-1996); Admiral William A. Owens, Jr. and Joseph S. Nye, "America's Information Edge," *Foreign Affairs*, (March/April 1996).

[266] Adm. Bill Owens, *Lifting the Fog of War*. See Gray, *Another Bloody Century*, p102.

[267] This is arguably the most common criticism of offence-defence theory. See, for example, John J. Mearsheimer, *Conventional Deterrence*, (Ithaca: Cornell University Press, 1983), p24-27; Samuel P. Huntington, "U.S. Defense Strategy: The Strategic Innovations of the Reagan Years," in *American Defense Annual, 1987-1988*, Joseph Kruzel (ed), (Lexington, Mass: Lexington Books, 1987), p23-43, at p35-37; Colin S. Gray, *House of Cards: Why Arms Control Must Fail*, (Ithaca: Cornell University Press, 1992), p28, 66-68; Colin S. Gray, *Weapons Don't Make War: Policy, Strategy, and Military Technology*, (Lawrence: University of Kansas Press, 1993), chpt 2; Jonathan Shimshoni, "Technology, Military Advantage and World War I: A Case for Military Entrepreneurship," *International Security*, 15 (Winter 1990-91)," p190-191; and Jack S. Levy, "The Offensive/Defensive Balance of Military Technology: A Theoretical and Historical Analysis," *International Studies Quarterly*, 28 (June 1984), p219-38. For example, Jervis argues that while ground warfare "is a contest between fortifications and supporting light weapons on the one hand, and mobility and heavier weapons that clear the way for the attack on the other…there is no simple way to determine which is dominant. Jervis, "Cooperation," p197. "No simple and unambiguous definition is possible and in many cases no judgment can be reached….[thus] whether a weapon is

example, may have been developed in order to break through an enemy's entrenched positions,[268] but so too can they be pivotal for defensive operations as well.[269] At the same time, determining the balance of technological advantage can be similarly problematic. In the Cold War, it was commonly assumed that American fighter aircraft were far superior to their Soviet counterparts. Yet once the Berlin Wall collapsed, Russian planes, such as the Su-27 Flanker and Mig-29, began touring Western air shows. Their exceedingly capable performance at these events—including during simulated dogfights against F-15 and F-16s—came as a shock to many observers. The technological balance was therefore much closer to parity than commonly assumed.

Given these methodological difficulties, "rigorous tests of offense-defense hypotheses have been surprisingly rare."[270] One proponent, for example, suggests that while "military technology can favor the aggressor or the defender," they then provide no criteria for determining which case is which.[271] Another offers that offensive technologies, "make it less expensive for states to seek security by adopting offensive military postures and strategies," and yet makes no indication of which technologies achieve this desired end.[272] It is therefore unsurprising that technology theory has in fact long suffered from a lack of systematic empirical

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offensive or defensive often depends on the particular situation—for instance, the geographical setting and the way in which the weapon is used." Jervis, "Cooperation," p201-2.

[268] Patrick Wright, *Tank*, (New York: Viking, 2000). One veteran saw the tank as "necessary if one side was to gain the advantage and put a decisive end to the grinding and deadlocked warfare of attrition" of World War I. Paraphrased by Wright, p54.

[269] See the German defensive battles described in Geoffrey Jukes, *Kursk: Clash of Armour*, (London: Macdonald, 1969); Erhard Rauss, *The Anvil of War: German Generalship in Defense on the Eastern Front*, (London: Greenhill Books, 1994); Erich von Manstein, *Lost Victories*, (Chicago: Henry Regner, 1958); and Major General F.W. von Mellenthin, *Panzer Battles: A Study of the Employment of Armour in the Second World War*, (Old Saybrook, CT: Konecky & Konecky, 1956), in which armour played a crucial role.

[270] Lieber, *Engineers*, p16. Lieber aims to help remedy this through a collection of cases studies; this chapter looks instead to a more quantitative methodology.

[271] Van Evera, *Causes of War*, p160. Observed by Lieber, *Engineers*, p39.

[272] Lynn-Jones, "Offense-Defense Theory and Its Critics," p674-75. Again observed by Lieber, p39.

testing.[273] This leaves a need to "formulate testable hypotheses [of technology theory] and to test them empirically."[274] What follows is therefore an innovative methodology outlining precisely how to do that.[275]

Testing Dyadic Technology

Dyadic theory is the most straightforward version of technology theory to test. Again, here is the argument that the belligerent with the relatively superior stock of technology will win the battles they fight. In effect, to the more technologically gifted go the spoils. The difficult part is finding a metric that can be used to effectively encapsulate the overall technological balance between two belligerents. Technology does not lend itself to straightforward metricization; the sum total of a nation's innovations cannot be easily be graphed.[276] Because of this challenge, efforts to systematically collect data on the role of technological advantage in war outcomes are decidedly rare.[277] One of the few such studies is Biddle's compilation of weapons

[273] Jack Levy, "The Offensive/Defensive Balance of Military Technology: A Theoretical and Historical Analysis," *International Studies Quarterly*, 28, 2 (June 1984), p219-38. For exceptions, see Biddle "Rebuilding Foundations," Ted Hopf, "Polarity,"; James Fearon, "The Offense-Defense Balance and War since 1648," presented to the annual meeting of the International Studies Association, Chicago, 1995. For other critiques, see Mearsheimer, *Conventional Deterrence*, p25-27; Dan Reiter, "Exploding the Powder Keg Myth: Preemptive Wars Almost Never Happen," *International Security*, 20, 2 (Fall 1995), p5-34; Jonathan Shimshoni, "Technology, Military Advantage, and World War I," *International Security*, 15, 3 (Winter 1990/91), p187-215; Kier Lieber, "Grasping the Technological Peace," *International Security*, 25, 1 (Summer 2000), p71-104.

[274] Lynn-Jones, "Offense-Defense Theory and Its Critics," p691; Glaser, "The Security Dilemma Revisited," p200.

[275] Although there have been numerous tests of technology theory regarding the modern era, the author is unaware of another study so chronologically-ambitious as this one.

[276] North's comparison of chronology, population, and specific inventions typify a common approach. While such a chart is extremely useful, such a methodology is obviously not an attempt to precisely quantify the sum total of technological achievement over time. Douglass C. North, *Understanding the Process of Economic Change*, (Princeton: Princeton University Press, 2005), p89; based on Michael Kremer, "Population Growth and Technological Change: One Million B.C. to 1990, *Quarterly Journal of Economics*, 108:3 (August 1993), p683 and Robert W. Fogel, *The Escape from Hunger and Premature Death 1700-2100: Europe, America, and the Third World*, (Cambridge: Cambridge University Press, 2003). For more reading on technology's role in history, see F.M. Scherer, *New Perspectives on Economic Growth and Technological Innovation*, (Washington: Brookings institution Press, 1999).

[277] Pierre Sprey, "The Case for Better and Cheaper Weapons," in Clark *et al*, *The Defense Reform Debate*, p193-210, offers an attempt, though it is more anecdotal than systematic. Other empirical studies, such as Stam, *Win, Lose or Draw*, include "technology" or "weapon quality," generally measured by defence expenditure per soldier. Unfortunately, these studies are unsuitable for our purposes here, given that this measure "conflates technology with training, pay, and quality-of-life accounts. It also biases the measure in favor of air and naval powers (whose

data for the period of 1956 and 1992. Biddle took the tank and ground attack aircraft used by the participants of 16 interstate wars during this time period, and used the date of their introduction as an index of technological sophistication; "the more recent the introduction, the more sophisticated the system, ceteris paribus."[278] Unfortunately, repeating such an innovative effort for the 2,500-year scope of this study is beyond available means. Instead, the best we can do is use a proxy to stand in as a rough approximation of the relative technological condition.

Modern efforts to gauge national stocks of knowledge and innovation have resulted in sophisticated measures, such as the World Bank's Knowledge Economy Index and the OECD's total factor productivity database.[279] Unfortunately, by incorporating the influence of institutional performance, neither purely reflects technological change. Nor do these figures extend back more than a few decades—at best. This leaves such measures ill-suited for the chronological breadth this study demands. Further metrics include patent applications, research and development spending, university degrees awarded, and scientist and engineer employment, but they are similarly hamstrung.[280] Some productivity estimates date back to 1870, but these again are too limited in temporal scope to be of use here, and furthermore exist for only a limited number of countries.[281] In the same way, the painstakingly collected data for average

militaries are more capital-intensive regardless of their technological sophistication), and against land powers (whose militaries are more labor intensive)." Biddle, *Military Power*, p251 fn #50.

[278] Biddle, *Military Power*, p25.

[279] World Bank, "Knowledge Economy Index (KEI)," annual, available at http://info.worldbank.org/etools/kam2/kam_page5.asp. The OECD's productivity database can be found at: http://www.oecd.org/topicstatsportal/0,3398,en_2825_30453906_1_1_1_1_1,00.html. For a discussion of calculating Total Factor Productivity (which the OECD labels 'multifactor productivity'), see World Bank, "PREM Notes: Measuring growth in total factor productivity," Number 42 (September 2000).

[280] Figures for these can be found at the World Bank's portal for social and economic indicators, http://data.worldbank.org/indicator. See also, US National Science Board, *Science & Engineering Indicators*, (Washington: annual). There has been work done to calculate total science and technology journal publications between 1665 and the present, but as far as the author is aware, these have not been broken down by nation, and thus cannot be used to determine a dyadic balance. Derek J. de Solla, *Little Science, Big Science*, (Columbia University Press, 1963), p9. See also Law and Kim (2003), cited in North, *Process*, p98.

[281] Scherer, *Technological*, p33; based on the work of William J. Baumol, Sue Anne Batey Blackman, and Edward N. Wolff, *Productivity and American Leadership: The Long View*, (MIT Press, 1989), p94; and Angus Maddison's

agricultural output/input ratios, compiled for five nations between 1880 and 1980, is unfortunately of little assistance here.[282]

Only two metrics are sufficiently systematic (offering data points at regular intervals), comprehensive (incorporating a satisfactory number of actors), and boast the chronological breadth (providing data as far back as the earliest battles in the dataset) to meet the needs of this study: population and economic product.[283] Together, these estimates give a sense of per capita wealth, a figure that stands as a rough approximation of a nation's technological condition. This method is predicated on the assumption that as wealth *per person* grows, so too does a given society's level of technology. Technology is, after all, a reflection of the intellectual and material capital devoted towards its development. "The universal experience is that, the more resources a community possesses, the more inventions it will make and adopt."[284] Most economists agree, arguing that innovation is at the root of economic growth. It is therefore hardly a stretch to expect that if there is economic growth, there will be innovation—or at least

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GDP data. Another interesting technique is to compare manufacturing productivity over time. When Adam Smith was researching the impact of specialization on production, he inspected a series of pin factories. In one he found average worker productivity to be 4,800 pins a day. In comparison, when a Cambridge scholar visited English pin factory two centuries later, average output per worker had grown some 167-fold, to 800,000 pins per day. Clifford F. Pratten, "The Manufacture of Pins," *Journal of Economic Literature*, vol. 18 (March 1980), p93-96; recounted in Scherer, *Technological*, p10. Such examples are, however, too crude to draw the degree of precision needed here.

[282] Yuijiro Hayami and Vernon W. Ruttan, *Agricultural Development: An International Perspective*, (Johns Hopkins University Press, 1985), p131, 467-71. For a broader discussion, see Marcel Mazoyer and Laurence Roudart, *A History of World Agriculture*, James H. Membrez (trans), (New York: Monthly Review Press, 2006).

[283] For population, see Massimo Livi-Bacci, *A Concise History of World Population*, (Maiden: Blackwell Publishing, 2007), John Duran, *Historical Estimates of World Population: An Evaluation*, (Population Studies Center, 1974), and especially Colin McEvedy and Richard Jones, *Atlas of World Population History*, (London: Penguin, 1978/1985), for country-by-country estimates. Leading examples of wealth estimates include David Landes, *The Unbound Prometheus: Technology Change and Industrial Development in Western Europe from 1750 to the Present*, (Cambridge University Press, 1969); Joel Mokyr, *The Lever of Riches*, (Oxford: Oxford University Press, 1990); and Angus Maddison, *The World Economy: A Millennial Perspective*, (Paris: OECD, 2002). Maddison, *Monitoring the World Economy:1820-1992*, (Paris: OECD, 1995), p117-47 discusses the methods used to measure real income at the national level at some length. For additional consideration of the difficulties involved, see William D. Nordhaus, "Do Real Output and Real Wage Measures Capture Reality?", in Timothy F. Bresnahan and Robert J. Gordon (eds), *The Economics of New Goods*, (Chicago: University of Chicago Press, 1997), p29-70; and Sean Clark, "Revealing Clio's Secrets: The Case for Historical Macromeasurment," *International Journal of Interdisciplinary Social Sciences*, Volume 4 (2009). Mokyr and Maddison, for example, disagree vociferously on the timing of the economic divergence between West and East.

[284] Cardwell, *Wheels, Clocks and Rockets*, p13. This effectively summarizes the mainstream view of the historiography of technology.

the adoption of cutting-edge, productivity-enhancing technology—as well.[285] In this way, the wealthier of two belligerents, at least in per capita terms, can be assumed to be technologically superior.

The most urgent question, of course, is: how valid is this technique? Intuitively, the logic behind a connection between per capita wealth, technological sophistication, and battlefield success is sound. Wealthy societies invariably enjoy more advanced technology than their poorer neighbours, and this discrepancy is commonly translated into military victory. The affluence of the Roman Empire, for example, allowed the Roman legion to be lavished with far more sophisticated weaponry than the impoverished horsemen of the Eurasian plain.[286] So too did Europe's capital intensity translate into the maritime technology that so bedeviled the navies of China and the Moghul states.[287] A similar discrepancy in wealth was found between European imperialists and the peoples of Africa, with the latter's technology proving utterly unable to match the invaders.[288] Nor has modernity diminished this connection. If anything, the fungibility between technology and wealth has growth. Take how at the outset of World War II, the US military's airframes were hopelessly outclassed by their German and Japanese rivals. What America could boast, however, was unsurpassed per capita wealth. In a short time, the country was therefore able to transform these resources into the long-range P-51 Mustangs that

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[285] See Robert M. Solow, "Economic History and Economics," *American Economic Review*, 75(2) (May 1985), p328-31; Gregory N. Mankiw, David Romer, and David N. Weil, "A Contribution to the Empirics of Economic Growth," *The Quarterly Journal of Economics*, (1992), p407-437; and Charles Jones, *Economic Growth*, (New York: W.W. Norton, 2001).

[286] See, for example, M.C. Bishop and J.C.N. Coulston, *Roman Military Equipment: From the Punic Wars to the Fall of Rome*, (Oxford: Oxbow Books, 2009). Nor were they alone. The "technology gap" between the societies of Caesar and Vercingetorix "was formidable, and the cost of building a new society [in the aftermath of the region's conquest] ruinous." G. Woolf, "Becoming Roman: The Origins of Provincial Civilization in Gaul," in *Roman Imperialism*, (Malden, MA: Blackwell, 2004), p231.

[287] See Cipolla, *Guns*. This case highlights the importance of the *per capita* nature of the metric adopted. China and India were of course, in aggregate, far wealthier than their Western rivals. Yet on a per person basis—a far more accurate measure of the nation's standard of living—they lagged badly. See Maddison, online.

[288] Donald R. Headrick, *The Tools of Empire: Technology and European Imperialism in the Nineteenth Century*, (Oxford University Press, 1981).

so denuded Germany of air cover in the latter stages of the war, and the F6 Hellcats that sent large numbers of the once-triumphant Japanese A-6M Zeros down in flames.[289] Even the Soviet Union, with its sacrifice of consumer production in favour of military spending, did not depart from this common pattern. Although such tradeoffs permitted the development of 'best-in-class' hardware such as the T-34 main battle tank and the Typhoon ballistic missile submarine, such achievements were generally singular in nature. Over all, despite such incredible devotion of material wealth to military production, balance of technology did not swing in Russia's favour. Indeed, few would suggest the Soviets went to war with in 1941 with kit superior to the Germans, at least in aggregate. The same would have been said of any prospective World War III comparison of Red Army and NATO forces. Lastly, Western Europe provides an interesting case for the opposite extreme. These countries are extremely affluent, but generally keep a close watch on military spending. Even so, the technology that they *do* adopt tends to be in accordance with their relative material standing. Canada, for example, will not be purchasing many F-35 fighter jets, but they will be some of the most technologically sophisticated money can buy.

If the concept is methodologically trustworthy, what about the data? Given the broad sweep of history undertaken in this study, the most comprehensive and easily comparable measure for technology is Maddison's (2007) per capita GDP data. These figures represent the most chronically and geographically broad estimates of capital intensity by region currently available. Given the slow pace of economic change in the preindustrial era, GDP levels have been assumed to extend for 50 years in either direction of the pre-1820 figures available (these

[289] The US entered the war with the obsolete P-39 Aircobra and the outclassed F-4 Wildcat, and yet ended the war little more than three years later with the top-flight F6 Hellcat, P-47 Thunderbolt, and P-51 Mustang. For a discussion of airpower in World War II, see Richard Overy, *The Air War: 1939-45*, (Potomac, 2005); also Bishop, *Weapons*; and Ronald H. Spector, *Eagle Against the Sun: The American War with Japan*, (New York: Vintage, 1985).

being the years 0 AD, 1000, 1500, 1600, 1700).[290] By adopting this interval, all battles within these ranges can be incorporated into the study. It will have to be demonstrated, however, that doing so is methodologically sound.

Evidence of the slow pace of economic change in the preindustrial era abounds. The West's main technological developments from the 6th to 11th centuries, for example, are found roughly a full century apart.[291] Agricultural yields performed little better. As shown in table 3.1, the three hundred years prior 1500 showed remarkably little growth in what is a preindustrial society's largest economic sector. Moreover, while growth slowly began to accelerate after this period, the pace was still relatively tepid. The 1500s and 1600s did, of course, witness a dramatic shift of wealth from southern Europe to north. But this took a considerable period of time to occur. Cipolla's charting of economic trends in the 16th and 17th centuries shows that all countries were prone to periods stagnation and decline, each of at least about 25 years.[292] Similarly interesting is how England, which had clawed from the periphery of Europe in 1500 to the top in 1700, took a steady 200 years to do so. Total blast furnace production in England and Wales measured 1,200 tons in 1530-9 (from 6 sites), 19,000 tons in 1620-9 (from 82 sites), and 24,000 tons in 1700-9 (76 sites).[293] Broader economic analyses confirm this trend, with real GDP per capital growth in Western Europe between 1500 to 1820 managing only about 0.2% per annum, half that in the rest of Europe and Latin America, and zero in Asia and Africa.[294]

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[290] The Dark Ages were not, it should be said, devoid of innovations. See David Landes, *The Wealth and Poverty of Nations*, (New York: W.W. Norton, 1999), p45.

[291] These innovations were the spread of the water mill (from 6th century); the heavy plow (through northern Europe in the 7th century); crop rotation (8th); the horseshoe and of a new method for harnessing draft animals (9th). Carol M. Cipolla, *Before the Industrial Revolution*, (New York: W.W. Norton, 1994), p138-9.

[292] Cipolla's interesting graphic is found in *Before*, p236.

[293] Cipolla, *Before*, p264. Worth noting is that *average* output of these blast furnace sites jumped only from 200 tons in 1530-9, to 230 in 1620-9, to 315 in 1700-9. This indicates that England's substantial jump in production came first (in the 16th century) from dramatic growth in the raw number of blast furnaces, followed by the 17th century's more moderate gains, which were predicated on efficiency gains.

[294] Angus Maddison, *The World Economy: A Millennial Perspective*, (Paris: OECD, 2001), p244.

Table 3.1 Average Gross Yields (per seed for wheat, rye, barley, and oats in selected countries, 1200-1699).

	Grains Yielded per Seed Planted		
Period	England	France	Germany
1200-1249	3.7		
1250-1499	4.7	4.3	
1500-1699	7.0	6.3	4.2

*Source: Cipolla, *Before*, p101. Originally from Slicher van Bath, "Yield Ratios," p15.[295]

With the advent of the industrial revolution, this assumption of relatively static economic conditions no longer holds. Spurred on by rates of economic growth previously unseen, the balance in per capita wealth between nations became far more variable during this time.[296] The increase in British cotton production, for example, jumped from about 1.4% per annum from 1700-~1745, to 2.8% until the 1770s, and then to a stunning 8.5% from about 1775 to the early 19th century.[297] In total, between 1760 and 1827, cotton production increased a hundred-fold. Although it would have taken some time for the effects of this remarkable technological growth (with the key inventions of the Hargreaves, Arkwright, and Crompton looms) to ripple through the rest of the economy, the direction is clear. The assumption of century-long technological stability no longer holds. Fortunately, after 1820, year-specific data is generally available,

[295] B.H. Slicher van Bath, "Yield Ratios 810-1820," *Afdeling Agrarische Gechiedenis Bijdragen*, vol. 10 (1963). See also his *Agrarian History of Western Europe 500-1500*, (London, 1963).
[296] For a discussion of the accelerated growth of technical progress since 1820, see Maddison, *Monitoring the World Economy*, (1995), chapter 2 and p71-3. Maddison disagrees with the traditional hypothesis (such as Simon Kuznets, *Modern Economic Growth*, Yale, 1966) that the modern period of rapid economic growth began in 1760.
[297] Samuel Lilley, "Technological Progress and the Industrial Revolution 1700-1914," in *The Fontana Economic History of Europe: The Industrial Revolution*, (Fontana, 1978), p195. Useful graphs are found on p196 and 201, with the latter treating the expansion of English pig iron production in a similar manner.

particularly in the case of Western Europe and its overseas off shoots. Thus as the pace of economic change accelerates, so too does the dataset's ability to account for it.

Also worth noting is that for long struggles, GDP per capita is held constant from the year of war initiation onwards. Thus GDP per capita figures for battles during World War I reflect 1914 data throughout. This has been done for two reasons: the first, to simplify calculation; the second, as a reflection of the fact that once wars begin, relative technology does not tend to change. For example, despite the wide swings in territory (and thus material wealth) during the Russo-German struggle of 1941-1945, Germany entered the war strong in precision engineering and Russia in mass manufacturing. No surprise, then, that Germany developed the first jet engine, while Russia built endless lines of armoured vehicles. The relative technological balance between the two did not change. Similarly, Ethiopia was not likely to develop a brand new research base during its wars with Eritrea. Even in the US-Japanese case cited above, although America went to war with a great deal of shoddy equipment, the overall technological condition—as evidenced by the massive discrepancy in per capita wealth—remained in America's favour. Nothing in the subsequent four years of total war would change this. Indeed, transformations of this type cannot be achieved so quickly, even when confronted by the exigencies of war.

Testing Systemic Technology Theory

While dyadic theory can be evaluated with a relatively straightforward examination of relative GDP per capita, testing for the systemic effects of military technology poses a much greater challenge. One such complication is that the utility these weapons confer is rarely

limited to one type of strategic posture.[298] Artillery, for example, was crucial to smashing open the German lines outside Stalingrad (1942-3), but so too was it vital to halting the German attack at Verdun (1916).[299] Likewise American diesel-powered, hunter-killer submarines roamed Japanese home waters, decimating the country's merchant marine in World War II. Today, however, diesel submarines are seen as ideal defensive weapons, with their relatively quiet engines handy for checking the advance of larger, more powerful battleship or carrier navies.[300] An ostensibly offensive weapon may therefore prove exceedingly useful during defensive operations as well.[301]

Another concern is that battles are conducted with a multiplicity of weapons, each with the potential to either accentuate or diminish the posture-favouring tendencies of other arms. Even the theory's most fervent supporters admit that "Individual weapons systems almost invariably combine technologies that can be labeled offensive or defensive" in nature.[302] Weapons must therefore not be considered in isolation, but rather as a component of a larger

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[298] For further arguments that weapons cannot be characterized as either offensive or defensive in nature, see Levy, "Offensive/Defensive Balance, p219-38; John J. Mearsheimer, *Conventional Deterrence*, (Ithaca: Cornell University Pres, 1983), p25-27; Samuel P. Huntington, "U.S. Defense Strategy: The Strategic Innovations of the Reagan Years," in *American Defense Annual, 1987-1988*, Joseph Kruzel (ed), (Lexington, MA: Lexington Books, 1987), p35-37; Shimshoni, "Technology, Military Advantage and World War I," p190-91; and Colin S. Gray, *Weapons Don't Make War: Policy, Strategy, and Military Technology*, (Lawrence: University of Kansas Press, 1993), chpt 2.

[299] Stalingrad opened, in the words of the historian Alan Clark, with "a new and terrible sound." This roar was "the thunderous barrage of Voronov's two thousand guns to the north," raining down on German positions for 80 minutes prior to the Russian counter-offensive. The spectacle was so great that, from 1944 onwards, Russians would call November 19 "Artillery Day." Cited in John Keegan, *The Second World War*. Artillery was also crucial to the Germans early success in the last, desperate *Kaiserschlachten* of 1918. See Martin Middlebrook, *The Kaisers Battles*, (Pen & Sword Books, 2007).

[300] Nuclear submarines are generally noisier because they require constantly-operating pumps to keep the reactor core cool. In contrast, diesel boats can lie in wait relying only on batteries, operating silently in comparison.

[301] The reverse is also true, with seemingly defensive weapons facilitating the attack. Quester, for example, notes that the net impact of fortresses—clearly a weapons technology designed to protect a particular terrain—may offer a net impact of favouring *offensive* action, given that fortresses can secure a sector and thereby free up troops for use elsewhere. Quester, *Offense and Defense*, p3-4, 15-17, 31-35, 63. During disarmament talks in the early 1930s, Germany argued that French fortresses were offensive in nature because they were situated so close to the border, meaning that they could be used as a base to launch an attack from. Boggs, *Attempts to Define and Limit 'Aggressive' Armament*, p46. Lieber argues that firepower can achieve the same result, making it easier to stop an attacker, but also allow an attacker to hold quiet sectors with labour-saving firepower and concentrate his forces towards numerical advantages in other attack sectors. Lieber, *Engineers*, p44.

[302] Lynn-Jones, "Offense-Defense Theory and Its Critics," p675.

pool of technology underlying battlefield conditions. Each specific technology adds to the total *net* balance, albeit with mechanical characteristics accentuated or diminished by prevailing conditions.[303] More importantly, when saddled with such difficulties it is easy to see just how difficult the offence-defence 'balance' is to measure.[304] Contemporary scholars have consequently "devoted far more effort to theorizing about the consequences of changes in the offense-defense balance than explicating how weapons technologies actually determine the balance."[305] Difficulty has bred an aversion to the task.

This is not to say that technology theorists have been silent on the matter. A rough logic has been offered to distinguish offensive from defensive weapons. One of the earliest and most notable efforts in this direction comes from Marion Boggs' 1941 study. "Armament which greatly facilitates the forward movement of the attacker might be said tentatively to possess relatively greater offensive power than weapons which contribute primarily to the stability of the defender."[306] In contrast, "The defense disposes especially of striking power and protection, to a lesser extent of mobility."[307] To put it more clearly, Boggs' assumption was that technologies that enhance mobility favour the attack, while firepower facilitates the defensive posture. This basic breakdown has remained largely until this day. Indeed, despite the "high degree of confusion and the fact that not all offense-defense proponents make these claims explicit, the

[303] Indeed, the magnitude of the effect of any given technology will "depend on…complex combinations of operational and tactical constraints and opportunities." Glaser and Kaufmann, "offence-defence", p73-74.
[304] Lieber has a useful survey of the systemic offence-defence literature in *Engineers*, chpt 1. See also the excellent reader Michael E. Brown *et al* (eds), *Offense, Defense, and War: An International Security Reader*, (Cambridge, MA: MIT Press, 2004).
[305] Lieber, *Engineers*, p38.
[306] Boggs, *Attempts*, p84-5.
[307] Boggs, *Attempts*, p84. Quincy Wright also looked to 'striking power'—firepower, in the modern vernacular—as the chief characteristic of defensive weaponry. Quincy Wright, *A Study of War*, (Chicago: University of Chicago Press, 1965), p805-10.

mobility and firepower criteria are the most employed hypotheses about the causes of the offense-defense balance."[308] We now move to consider if this assumption has been a wise.

The Current Model and Its Failings: Mobile Offence and Defensive Firepower

The mobility-favours-offence hypothesis has a long and noteworthy pedigree. Even before Boggs, Fuller wrote that "As long as armies are small enough to maneuver freely, and are commanded by generals with an equally mobility of mind…offensive power will be high."[309] Liddell Hart echoed this sentiment, championing "the view that the tank provided the means to restore mobility on the battlefield and make it possible, once again, to win quick and decisive victories." For him, the tremendous *mobility* of mechanized forces in would make the "lightning strokes" necessary for rapid victory possible.[310] More recently, Quester concurred that mobility…

> "generally supports the offensive. First, one can invade with impunity if one can bring along all the 'comforts of home,' all of one's most deadly vehicles of destruction. Second, the ability to move may allow an attacking force to exploit various weak spots or blind spots of the force that is standing in place…Third, the ability to move allows an

[308] Lieber, *Engineers*, p35. This distinction between mobility and firepower is found not only in the international relations literature, but also the arms control policy community. See, for example, Catherine M. Kelleher, "Indicators of Defensive Intent in Conventional Force Structures and Operations in Europe," in *Military Power in Europe: Essays in Memory of Jonathan Alford*, Lawrence Freedman (ed), (New York: St. Martin's Press, 1990), p159-78; Anders Boserup, "Mutual Defensive Superiority and the Problem of Mobility Along an Extended Front," in *The Foundations of Defensive Defense*, Anders Boserup and Robert Neild (eds), (New York: St. Martin's Press, 1990), p63-78; and Guinilla Hesolf, "New Technology Favors the Defense," *Bulletin of Atomic Scientists*, 44 no. 7 (September 1988).

[309] J.F.C. Fuller, "Aggression and Aggressive Weapons: The Absurdity of Qualitative Disarmament," *Army Ordnance*, 14 (1933), p7-11, at 9. See also Brian Holden Reid, *J.F.C. Fuller: Military Thinker*, (New York: St. Martin's Press, 1987), p67. Unsurprisingly, Fuller was one of the interwar period's leading exponents of mechanized warfare.

[310] John Mearsheimer, *Liddell Hart and the Weight of History*, (Ithaca: Cornell University Press, 1988), p36. It is true, however, that as the World War II loomed Liddell Hart engaged in a stark reversal, arguing that mobility instead favoured the *defensive*, permitting as it did the redeployment of forces to threatened sectors along the front line. Liddell Hart, *Memoirs*, p186. Hence his caveat that "despite the apparent advantage that mechanization has brought to the offensive, its reinforcement of the defensive may prove greater still." Cited in Mearsheimer, *Liddell Hart*, p114.

> attacking force to group itself, to assemble temporary numerical superiorities as it pleases, when it decides to begin battles."[311]

Although Jervis is more reserved, suggesting that "there is no simple way to determine which is dominant," he nonetheless offered that ground combat "is a contest between fortifications and supporting light weapons on the one hand, and mobility and heavier weapons that clear the way for the attack on the other."[312] Mobility can therefore be seen as one of Jervis' crucial distinctions between offensive and defensive technology. Indeed, for him it is "total immobility" and "anything else that can serve only as a barrier against attacking troops" that define a purely defensive system.[313]

The latest treatments of the subject have drawn roughly the same conclusions. In Kaufman and Glaser's assessment, mobility can be seen at the heart of what makes technology privilege one force posture over another:

> "The most critical question in this process is how the innovation differentially affects advancing forces and nonadvancing forces. Innovations that are usable only or primarily by nonadvancing forces will tend to favor defense, while innovations that are equally usable by forces that are advancing into enemy-controlled territory will favor the offense."[314]

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[311] George H. Quester, *Offense and Defense in the International System*, (New York: John Wily, 1977), p3. As Lieber notes, however, this argument is somewhat undercut by Quester's contradictory empirical examples. Whereas the appearance of the mounted warrior in the 4th century is seen by Quester to strengthen the offence as a consequence of this improved mobility, the emergence of the mounted knight of the 10th century is seen to strength the defence, given that the knight was dependent on the castle for financial support, thereby limiting the range of his willingness to fight. Lieber, *Engineers*, p38. See also Quester, p28-29, 30, 34, contrasted against 31 and 34.

[312] Jervis, "Cooperation," p197. Attempting to assess the technological balance of the year he was writing (1978), Jervis was "unable to render any firm judgment." Jervis, "Cooperation," p198. "No simple and unambiguous definition is possible and in many cases no judgment can be reached," hence his conclusion that "whether a weapon is offensive or defensive often depends on the particular situation—for instance, the geographical setting and the way in which the weapon is used." Jervis, "Cooperation," p201-2.

[313] Jervis, "Cooperation," p203.

[314] Glaser and Kaufmann, "Offense-Defense," p61. In fact, Glaser and Kaufmann examine the offense-defence impact of technology in light of six separate areas aspects: mobility, firepower, protection, logistics, communication,

The reason they cite for this distinction is that improved mobility amplifies the attacker's innate advantage: control of the initiative. Mobility-enhancing technologies make it even easier for attackers to outflank or overwhelm a surprised defender. Furthermore, enhanced mobility reduces the time an attacker must take to assault defensive positions.[315] This matters because losses are partly a function of how long assaulting forces are exposed to enemy fire.[316] In this way, an attacker's speed is of the essence.

Lieber succinctly explains the mobility logic with a simplified model. Consider a world comprised of just two states, each inhabiting an isolated island, and with no means of transport to bridge the divide between them. Here the complete lack of mobility can be seen as inherently defensive, since foreign conquest is simply not an option. The addition of watercraft, however, would change everything. With a newfound means to cross the water, offence suddenly becomes no longer impossible.[317] In this way, we can see how mobility is more crucial to the attacker than it is to the defender, at least in simplified circumstances.

Concomitant to the mobility argument is the assumption that advances in firepower[318] leave the defender relatively more secure. "In battle, attackers are usually more vulnerable to fire than are defenders." This is because attackers "must advance, often in plain sight of defenders, making them easy to detect and to hit, whereas defenders are often well dug-in and

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and detection. Here the discussion is in regard to their take on mobility and firepower. They do also, however, consider the other four: "The effects of innovations in protection, logistics, communication, and detection are more varied, depending on how specific innovations interact with force behavior behaviour; those whose full benefit can be realized only by non-advancing forces or only against advancing ones will favor defense, whereas those with benefits that are equally available to both advancing and nonadvacing forces will favor offense (at least compared with technologies of unequal usefulness)." Examples include how landline telephones favoured defence while portable radios favour offence, and how early radar was more favourable to defence than is modern radar. Though interesting, these aspects are much more ambiguous and tentative than the mobility and firepower hypotheses considered here. Glaser and Kaufmann, "Offense-Defense," p64.

[315] Glaser and Kaufmann, "Offense-Defense," p62-63.

[316] Glaser and Kaufmann, "Offense-Defense," p62-63.

[317] Lieber, *Engineers*, p41.

[318] Which is not only a matter of explosive power, but also of range, accuracy, and rate of fire. Lieber, *Engineers*, p43.

camouflaged."[319] Thus the more destructive the firepower of the day, the more an attacker will suffer—at least relatively—as they advance on the defenders' position. Exacerbating this fact is the attacker's need to concentrate his forces in a local advantage of combat power in order to achieve a breakthrough of the defender's outer perimeter. Such density makes the attacker more vulnerable than defenders to area-effect firepower, and therefore again subject to proportionately higher casualty rates. A further reason firepower favours the defender is that firepower reduces the mobility of the enemy, and hence their offensive power. "In the face of greater defensive fire, an attacker must seek more armored protection, cover, concealment, and dispersal—all of which slow the attacker's advance."[320] Last is that defensive firepower forces attackers to conduct preparatory suppression bombardments of their own. This, in turn, slows down the attacker's advance even further, adding still further challenge to the offensive.

To help clarify this logic, Lieber once again suggests a simplified model to explain the relative value that firepower offers to a defender.[321] Returning to our hypothetical world of two island states, separated by deep water and provisioned only with canoes, we can see how the introduction of rifles or cannons favours defence more than offence. Adding guns would, of course, dramatically improve the striking power of both belligerents. Yet their effect would not be equal. Attackers, after all, would have no choice but to travel, unprotected and over open water, through this 'storm of steel.' This operation would be significantly more dangerous than that of the defenders firing from emplaced positions on land.

Despite the rough consensus undergirding the mobility-firepower dichotomy, there are dissenters who offer powerfully challenging claims. Van Evera, for example, argues that

[319] Glaser and Kaufmann, "Offense-Defense," p64.
[320] Lieber, *Engineers*, p44. This slowed pace exposed the attacker to gradual attrition, particularly by defensive artillery. Biddle, *Military Power*, p45. For the rest of the discussion, see Lieber, *Engineers*, p43-44.
[321] Lieber, *Engineers*, p44.

mobility instead favours the defence: "In modern times, technology that gave defenders…greater mobility…strengthened the defense, [just as] technologies that favored chariot or cavalry warfare…strengthened the defense."[322] Lieber elaborates this concern, arguing that while mobility may be very useful for attackers at the tactical level, there is little reason to think that an ability to move troops at the strategic level (that is, from the theatre rear to the front lines) is of any more advantage to attackers than it is to defenders. Meanwhile, at the operational level, attackers appear to rely more on surprise than mobility, whereas the defender "places a premium on mobility to reinforce threatened points in the front."[323] Unless offensive success is achieved so rapidly that the defender has no time to react, mobility would seem to favour the defender once an advance is underway.[324] Even at the tactical level, attackers may pay dearly for their improved mobility, given that the more rapid the pace of advance, the less likely the normal reconnaissance, protection, and preparatory artillery fire capabilities are to be undertaken, thereby increasing attacker casualties.[325]

Nor is firepower universally assumed to improve a defender's prospects. Lynn-Jones, for example, argues that firepower-heavy weapons like cannons, siege machinery, and tanks are generally offensive in nature.[326] Quester, too, found the longbow, musket, and cannon as having strengthened the power of the offensive greatly. This stands rather awkwardly with his concurrent assertion that more recent advances in firepower favoured the defence.[327] Jervis

[322] Van Evera, *Causes of War*, p160. This argument is contradicted, however, by his assertion that "revolutionary France's mass armies strengthened the *offense* because they had greater mobility." [emphasis added]
[323] Lieber, *Engineers*, p40-41.
[324] See Lieber, *Engineers*, p41; Mearsheimer, *Conventional Deterrence*, p25-26. Glaser and Kaufmann acknowledge this.
[325] Lieber, *Engineers*, p41.
[326] Van Evera, *Causes of War*, p667, 676.
[327] Quester finds, for example, that 17th century artillery restored advantage to the defence. "Artillery after all is not useful only for battering down walls. If mounted properly within walls, it can perhaps cannonade the besieging forces before they succeed in getting their artillery into place. Once fortified structures were redesigned to exploit

similarly makes the mobility-firepower dichotomy less straightforward than its proponents would prefer, arguing specifically that light weapons, machine guns, and nuclear weapons favour defence, while heavy weapons and artillery favour offensive operations.[328] In the same vein, Van Evera contends that while the development of fast-firing rifles has bolstered defenders, the technologies that favour the mass production of small arms at the same time strengthen attackers.[329] As Lieber explains, firepower is in fact crucial to an attacker's advance as well. Suppression fire in particular can reduce a defender's capacity to resist by neutralizing an opponent's troops, weapons, or reconnaissance capabilities. Preparatory barrages can also forestall reinforcements, disrupt communications, disperse concentrations of counter-attack forces, and shatter morale.[330] Improved firepower therefore makes it easier to pin down an opponent until they are either bypassed or destroyed. It is thus not completely clear that defenders have the most to gain from technological breakthroughs in the firepower technology. Observers can therefore be forgiven for going away from this discussion harbouring a good deal of confusion.

Tracking Technology's Effect

This literature review has revealed a good deal of disagreement over how to classify the offensive and defensive nature of weapons. The question, then, is how best to evaluate the historical evidence.[331] It would be easiest if the historiography of war offered neat divisions

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artillery…the balance could again being to shift to the defence." Quester, *Offense and Defense*, p45-48, 60, 100-22. Observed by Lieber, *Engineers*, p43.

[328] Jervis, "Cooperation," 191-2, 197.

[329] Van Evera, *Causes of War*, p160-61.

[330] Lieber, *Engineers*, p44.

[331] As Lieber argues, "Proponents of offense-defense theory might emphasize that whether these technological characteristics are more useful in the attack or defense is a question not easily considered in logical isolation. Instead, they might argue that the mobility-favors-offense and firepower-favors-defense propositions derive from battlefield evidence and should ultimately be assessed against the historical record." Lieber, *Engineers*, p45. That is essentially the stance taken here.

between epochs dominated by one strategic posture or another. This would make it straightforward to compare technological conditions with how well particular strategic postures fare in battle. Unfortunately, very few historical works have sought to define eras as explicitly dominated by offence or defence. The Brodies' examination of antiquity, for example, discusses heavily artillery marvels such as the Roman ballista, onagers, and catapaults, yet does not unequivocally assign a favoured force posture to their use.[332] Dupuy's discussion of the "Age of Gunpowder" incorporates periods of both great offensive achievement, such as Napoleon's relentless hounding of his enemies in northern Italy, and also great defensive success, most notably demonstrated by the fortresses of Vauban.[333] These leave the reader uncertain of where the technological balance lay during such broad periodizations.

The consequence of this is that technology theory cannot be tested according to the mechanical qualities of prevailing weaponry. But we can look for ways to track technology's secondary effects. In this the most effective means at our disposal is to examine key battles and campaigns and observe whether or not technology holds a consistent effect—termed here 'epochal stability'—on victory and defeat. The question is not so much the offensive or defensive nature of weapons themselves, but rather if the overall effect of weaponry in a given age biases battle outcomes in favour of particular strategic postures. In other words, if technology really does play a crucial role in determining battle outcomes, one must observe consistency in the posture of victors for as long as that technology is said to exert an influence. Doing so requires dividing the empirical record into discrete units of time and looking for

[332] Bernard and Fawn M. Brodie, *From Crossbow to H-Bomb*, (Bloomington: Indiana University Press, 1973), p14-27. This is not to say that such a focus is unworthy. By the fourth century the Roman legion had a ratio of one siege engine to every hundred infantry, versus just three for every thousand of Napoleon's (p27).

[333] "A sixteenth century fortress, if provided with adequate stocks of food and ammunition, was as impregnable as the thirteenth-century castle had been in its day. By the latter part of the sixteenth century sieges had again become the slow, elaborate undertakings they had been two centuries earlier." Trevor N. Dupuy, *The Evolution of Weapons and War*, (Fairfax, VA: Da Capo Press, 1984), p109. The architects Daniel Speckle and Simon Stevin also deserve credit for their contributions to Renaissance fortifications.

consistency between force posture and victory in each block. Eras dominated by offensive technology will, the theory predicts, consist primarily of battles won by offensively-oriented forces. And while it is true that any observed consistency between victory and force posture may be for reasons entirely exogenous to technology, such a relationship is nonetheless a crucial precondition to proving technology theory correct. Although any prospective link between technology theory and epochal stability will require further connection to specific weapons developments—to demonstrate that this causal mechanism is truly at play—technology theory can only be verified if this first threshold of evidence is met. Epochal consistency is therefore a crucial empirical test that the theory must pass if verification is to be achieved.

The search for epochal consistency can be done in three parts, with each set of chronological intervals decreasing in historical breadth as they get closer to the present. This is done partly because of insufficient data. The Dark and Early Medieval ages are particularly short of the battle details necessary to track attacker success. Large periods of time are thus needed to incorporate even a modestly sized sample of battles. Such chronological breadth need not be fatal to the exercise. The first set is divided into 500 year intervals for the period -500 BC to 1500 AD. Although this interval is quite long, given that the relatively consistent pace of technological change for this period was glacially slow, it is sufficient to illustrate the broad technological dynamics of the age.[334] By the Renaissance, however, the pace of technological change began to accelerate, making it necessary to shorten the chronological breadth of the samples as much as possible. Therefore, from 1300—shortly after the introduction of

[334] Dupuy traces the growth in the lethality of the weapons of war over time in his *Attrition*, p26-7. In terms of early weapons, only individual missile weapons demonstrated any serious growth during this time. More specifically, javelin and bow technology slowly improved, culminating in the longbows and crossbows of the medieval period. See also his *Numbers, Predictions, and War*, (Indianapolis: Bobbs-Merrill, 1979). For a brief, visual explanation of the evolution of the Roman *pilum*, see John Warry, *Warfare in the Classical World*, (London: University of Oklahoma, 2006), p133.

gunpowder weapons to the battlefield[335]—onwards the test for attacker victory prevalence is performed in units of 100 years.[336] Lastly, we can break down the more plentiful recent data even further, into roughly quarter-century intervals.[337] These divisions, available from 1700 onwards, are useful for when the pace of technological innovation soared to new heights. More importantly, by shortening the period of time between measures we can contrast the returns to strategic posture against the predictions offered by others in the literature.[338] Most, for example, view the period 1900-24 as dominated by the machine gun, barbed wire, and long-range artillery, and thus extremely favourable to defence. In contrast, the next fifty years, dominated as they were by the tank, the airplane, and the radio (which appeared in the second, but matured in the third), were much more conducive to the attack—particularly in the latter period. The last quarter century, characterized by the proliferation of precision-guided antitank and anti-aircraft missiles, is seen as returning the technological balance to the defence. Breaking down the attacker success rate data into these intervals enables us to assess if these predictions are

[335] The first known illustration of a bombard in Europe (dated 1327) bears a striking resemblance to the earliest picture from China (dated 1128). These weapons certainly had a striking effect. A contemporary chronicle tells us that when the English laid siege to Berwick-upon-Tweed (then just over the Scottish border) in 1333: "They made many assaults with guns and with other [siege] engines to the town, wherewith they destroyed many a fair house; and churches also were beaten down unto the earth, with great stones that pitilessly came out of [the] guns and of other [siege] engines. And nonetheless the Scots kept well the town…[so that the English] might not come therein….[But they] abided there so long, till those that were in the town failed victuals; and also they were so weary of waking that they knew not what to do." Cited from Parker, *Warfare*, p102.

[336] As a comparison, the pre-modern 'patterns' of war described by Addington—"the unique social-political, technological, and organizational" consistencies found within a particular period (pxi)—are roughly broken into *pre-civilized war* (200,000-3200 BC), *warfare in the Near East* (3200-500 BC), *early Western warfare* (499-362 BC), *war in the Age of Rome* (509-476 AD), *war in the Middle Ages* (~500-1453), *early Modern warfare* (1494-1721), and *neo-classical war* (1725-1789). In this light, the epochal breadth used here looks hardly out of place. Larry H. Addington, *The Patterns of War Through the Eighteenth Century*, (Bloomington: Indiana University Press, 1990.

[337] The use of 25-year increments should prove sufficient even for the breathtaking pace of technological change in the 20th century.

[338] See Biddle, *Military Power*, p23, 251 fn45. See also, Ropp, *War in the Modern World*, p267-70; Brodie, *Crossbow to H-bomb*, p124-232, 281-89; Charles Messenger, *Blitzkrieg*, (London: Ian Allen, 1976). As Biddle notes, some view the postwar era as completely defensive in nature, given the tremendous destructive power of nuclear weapons (i.e. Van Evera, *Causes of War*, p). Those who restrict their analysis to non-nuclear conflict, however, generally arrive at the same periodization. See, for example, Quester, *Offense and Defense*, p163-70; David Gates, "Area Defense Concepts: The West German Debate," *Survival* 29, 4 (July/August 1987), p301-17; Bjorn Moller, *Common Security and Nonoffensive Defense*, (Boulder: Lynn Reiner, 1992).

accurate. So not only must the results indicate a sharp bias in the returns to either offence or defence, but that this skew coincides with the posture presumed to be dominant at the time.

The degree of offensive 'success' can be measured in two ways. The first is in terms of outright attacker victory or defeat. Does the attacker win the battle they initiate, or lose it? The second is a more nuanced measure of success, concerning itself not with winning or losing *per se*, but rather how well the attacker performed during the engagement. This measurement of 'relative battle performance' can be done through comparison of attacker and defender casualty rates. This raises the question, however, of attacker identification. It is not easy to determine who fired the first shot, or even which army crashed into the other first, when Clausewitz's 'fog of war' obfuscates the movements and commands of even the most well-organized of military forces. That being said, even battlefields of mutual choosing are decided by the forcing of one strategic vision over that of another. The Macedonians and Persians fought along Gaugamela ultimately not because the Persian king Darius III favoured the flat plains for his chariots, but because Alexander had marched headlong into his empire. The definition used in this study is therefore a function of *geographical* reality. Who has moved to intercept? Who has moved to crush their opponent?[339] In cases of uncertainty the decision falls to an evaluation of strategic intent and current initiative. Who is running after whom? Thus while armies can run into each other for reasons of sheer luck, such as at Cynoscephalae (197 BC), the concern is whether or not the maneuver was part of a larger objective to initiate hostilities on an enemy's territory. In this case, this is precisely what the Romans were doing, and thus the designation 'attacker' is ascribed to them.

[339] This is similar to the COW's definition as the attacker, or "initiator", as the state that takes the first codable action of a militarized interstate dispute, and the "target," or the state that the is the direct object of that action. It also is in line with John Arquilla's defining a war's initiator as the "side that started the actual fighting, or first seized either some of the homeland or valued territorial or property interests of another state or states." John Arquilla, *Dubious Battles*, (Washington: Crane Russak, 1992), p6.

3.3 Data Analysis

H(T)*d* ('dyadic' technology)

The expectation of dyadic technology theory is that when two opposing armies meet in battle, the technologically superior will win. The historical evidence, however, suggests caution before making this assumption. Of 475 available battles, the side with greater per capita GDP wealth—our proxy for the belligerent's technological condition—emerged victorious 63% of the time. Although this figure stands higher than the aggregate preponderance findings discussed above, it will bring only marginal comfort to generals pacing nervously on the eve of battle. Such unease is the consequence of the fact that not only is this number still dangerously close to the results of flipping a coin, but that it is also somewhat skewed by the large number of battles which were fought in the 20th century (some 211 out of the total). Here victory was visited upon the technologically superior 73% of the time, a much more impressive rate which far outstripped most other periods. Only the 1800s and 2000s exceeded a 60% return to technological supremacy victory, while the rest hovered near 50% or worse. Perhaps if the 20th century did not loom so large in the dataset the results—perhaps for reasons of data insufficiency regarding other periods—would be even less kind to dyadic theory's already unimpressive aggregate returns.

Table 3.1 Dyadic Explanatory Efficacy (0-1499 for first interval, by century thereafter).

	Total Battles	# of > GDP per cap Victories	% of > GDP per cap Victories
0-1499	7	4	57.1
1500-99	12	4	33.3
1600-99	16	8	50.0
1700-99	71	37	52.1

1800-99	153			96		63.1
1900-99	211			151		71.6
2000-present	5			3		60.0
Overall	*475*		*303*		*63.9*	

*All data available in dataset.

Still, it may be that the sample is comprised of decidedly different populations. Perhaps the trend, starting in the 1600s, of an increasingly decisive role for technology in battlefield outcomes is the consequence of a newfound reliance on the machinery of war. After all, the industrial revolution transformed political, economic, and social affairs. Why not war as well? To this two reasons for caution must be offered. First is that the (admittedly statistically insignificant) post-2000 period suggests that the potency of technology has declined once again. If the suggestion is that technology is playing an ever-more crucial role in determining battle outcomes, we should expect favourable returns in an era dominated by the internet and mobile computing as well. On this, the jury is still out. Second, the massive gap in technological between belligerents opened up by the industrial revolution may have 'stacked the deck' in technology's favour. As figure 3.1 illustrates, differences in technology between two armies became inordinately extreme in the 1800s and 1900s. This gap was the consequence of some parts of the world having gone through the scientific and industrial revolutions while others not. Partly because of this asymmetry, the former showed a strong proclivity for invading the latter. They did so with almost invariable success, handing Western Europe in particular a splendid overseas empire. This suggests that technology's assurance of victory is most pronounced when the technological gap between belligerents is wide.

We will return to this notion in a moment. More immediate, however, is the trouble these findings pose for dyadic theory. It is an acute problem for the theory if its confirming results rely heavily on such massive discrepancies in technology. This is because the conditions of the 19th and 20th centuries appear to be an aberration. Never before had such a divergence in technological capability between rival armies been seen. For all the trappings of civilization the Romans wore as they marched into the dark, barbarian forests of Germany, their *gladius* swords were not more potent than those of the tribes of Teutoberger Wald by any order of magnitude. Italian steel was not unfathomably harder; their blades not appreciably sharper. But when the British fought the Zulus at Ulundi (1879), the two armies might as well have been from different planets. Nor was this engagement anywhere near an isolated event. Headrick tells us that:

> "Confrontations between Europeans and Africans after 1870 rank among the most lopsided in history. For Africans these encounters brought bewilderment and hopeless struggles, while for Europeans they resembled hunting more than war"[340]

What is important to note, however, is that this era of gross technological disparity may be fleeting. Recent decades show powerful trends of economic and technological convergence between East and West.[341] China and India are now crucial hubs in the high-tech computing and information technologies industries. The former has already set stealth fighter and aircraft carrier to field trials. Even poor countries, mired in rates of slow growth and political instability, combat forces show a deft appreciation and aptitude for technology. Few, for example, would deny the Taliban's proficiency with internet recruiting and wireless detonation. More to the

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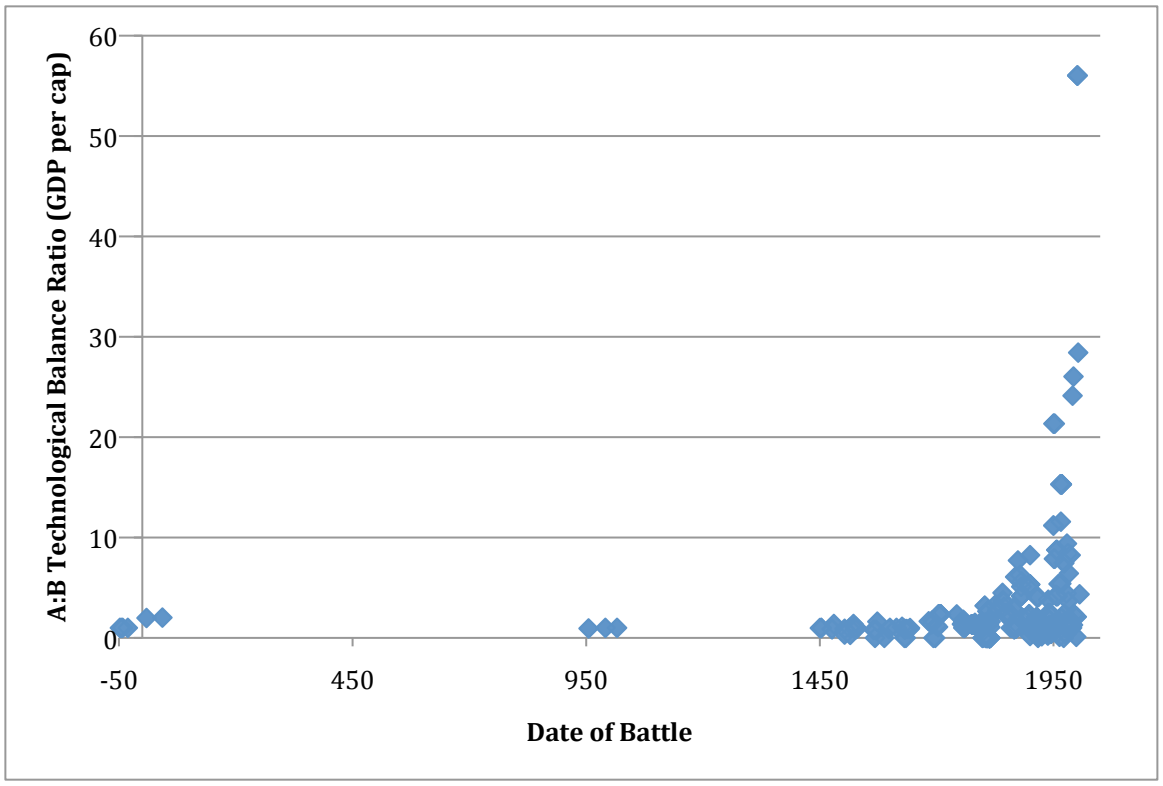
[340] Daniel R. Headrick, *The Tools of Empire: Technology and European Imperialism in the Nineteenth Century*, (New York: Oxford University Press, 1981), p115.

[341] See, for example, Sean Clark and Sabrina Hoque (eds), *What Lies Ahead: Debating the Prospects for a Post-American World*, (London: Routledge), in press. Meanwhile, Charles Jones argues we are witnessing income convergence—although slow and not amongst the poorest countries—because society gradually discovers and adopts successful institutions and policies conducive to econ growth. Jones, *Economic Growth*, (New York: W.W. Norton, 2001), p73-4, 153.

point, if this path of technological convergence continues, a return to technology theory's previous low returns on investment is likely. The findings here suggest that, lacking great gaps between one army and another, generals and policy makers in the coming decades will find no solace in technological supremacy.

Figure 3.1 Technology Gap, by Date (A:B GDP per capita).



*Based on 419 battles, ranging from Pharsalia (48 BC) to Lebanon (2006).

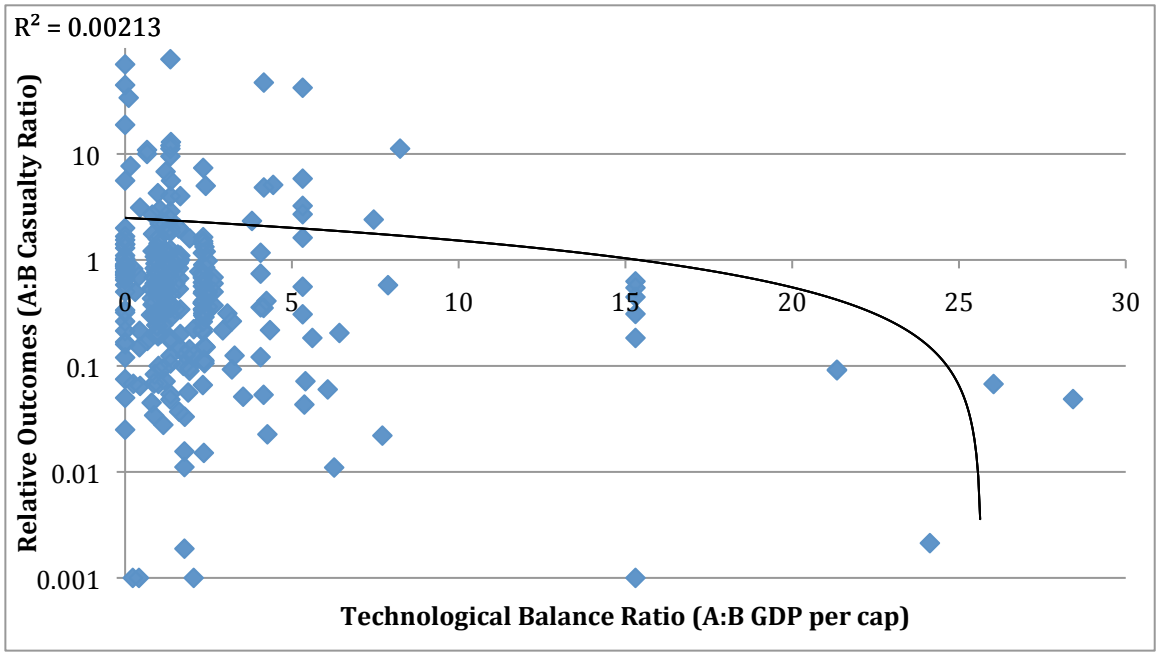
But what of the more general proposition? Perhaps technology is of little use in circumstances where the opponents are evenly matched, but performs well when the gap between belligerents is wide. In other words, does ever-greater technological supremacy lead to more impressive victories? If this were the case it would explain why the aberrant 20th century performed so much more in line with the theory's predictions. As the technological disparity

went up, so too did the percentage of cases where the technologically supreme emerged victorious. Such descriptive statistics do not, however, tell us the relative causal pull of technology in different circumstances. For that we must turn to inferential statistics. More specifically, the next step will be to see how well military performance correlates with the independent variable of technological supremacy. For each unit increase in the technological balance, with is the degree of improvement in battlefield performance does it bring?

The shift towards inferential statistics means that the win/loss variable is no longer sufficient, for it is categorical in nature and therefore does not lend itself to scatterplots or regression analysis. Instead, we must look to 'relative battlefield success.' A crude but useful measure of this is the ratio of casualties between belligerent A and belligerent B. True, the balance of blood spilled does not perfectly encapsulate battlefield victory. Many armies endure more losses per capita than their opponent, yet still emerge from the field victorious.[342] Nonetheless, the effort is both practical and theoretically relevant. The logic of technology theory asserts that the side with superior weaponry should emerge victorious. It stands to reason that in doing so it should also put its weapons to good use as well. Indeed, it is by no means a stretch of the theory's logic to assume that superior technology of one strategy posture dampens the effects of the other's, with the consequence of fewer casualties incurred. The expectation of the graph is therefore that the line of best fit should be a clear diagonal, from the top left quadrant to the bottom right. In other words, as technology gap between belligerents goes up, the casualties endured by the superior side should go down.

[342] For this and other reasons mentioned in chapter one, the study has chosen geographic control as its dependent variable, not relative performance. Given that lack of available ratio data measuring geographic control, relative performance will have to suffice.

Figure 3.2 Dyadic Technology Theory Performance (A:B technology balance, with per capita GDP as proxy, vs A:B relative battle success, using casualty figures).



*Based on 226 battles, ranging from Munda (45 BC) to Lebanon (2006).

It becomes quickly apparent that this relationship is not at play. Only in cases of extreme technological imbalance, shown at the far lower right of the graph, is the tendency to achieve a low level of relative casualties achieved. For the rest of the cases, the causal effect of technology appears to be slight. Overall, the R2 value is a miniscule 0.002, indicating that most plots shy far from a linear line of predication. Rather than a decisive trend indicating that superior technology is rewarded with lower casualties, the plots appear randomly scattered—a lack of causal direction reflected in the mostly static nature of the trend line. A simple Pearson correlation test confirms these findings. The coefficient is in fact *negative*, at -0.046 (with a *t* value of -0.777 and *p* value of 0.438). This is opposite to what the theory predicts, indicating that technology may be as much of an encumbrance as a benefit. The only possible conclusion is thus that improving one's relative technological position does not consistently result in improved

battlefield performance. The technologically superior of two armies cannot be certain they will garner the spoils.

Hypothesis H(T)*s* ('systemic technology')

Now that dyadic theory has been seen to fare poorly in light of the available historical evidence, we must turn to consider the systemic variant. As discussed above, the best way to test this hypothesis is to uncover whether or not there exist clear patterns of offensive and defensive success. Again, the assumption made by systemic theory is that technological conditions favour one strategic orientation or the other. Battle outcomes should therefore trend towards the associated military posture for as long as technological conditions remain the same. If, for example, the predominant weaponry within a particular 50-year span favours defensive action, we should see low rates of attacker success for that period. More specifically, the best way to define 'high' and 'low' rates of military success is to compare the results of a specific period with the mean of the aggregate sample. Of the 612 battles in the dataset that boast sufficient data to test for the relationship between technology and battlefield victory, the attacker won in 378 instances, or 61.8% of the time. This percentage provides a good baseline from which to judge whether or not a pattern of attacker success is clear. Performance roughly 5% above the mean (67%) suggests that the epoch was relatively favourable to the offense; 5% below it (or 57%), to the defender. The stronger the deviation from the mean, the more pronounced the favouring of the strategic posture. With this in mind we can now consider each interval in detail.

-500 BC to 1500 AD

We begin by breaking into 500-year blocks the two thousand years that span the rise of antiquity's greatest empires to the onset of the Renaissance. The results obtained conform well with our historical understanding of the period. During the early imperial epoch (-500 to -1 BC),

great and ambitious generals took up the Assyrian imperial mantle and established vast empires throughout the Mediterranean and Near East. Each ruthlessly and relentlessly added territory to their banners, and attacker success stood at an impressive 76.9% of battles fought. Empire building flourished when leaders could count on their armies to systematically win the battles. The reliability of offense is the crucial precursor to any society whose lifeblood is predicated on military success. The pace of attacker success slowed, however, to 57% during the epoch of imperial height (0 to 500 AD), a period so defined because it coincides with the apogee and considerable retrenchment of both imperial Rome and Han China.[343] In contrast, empires collapsed outright when military adventurism became a haphazard proposition at best. Even with only a small sample to consider,[344] the dreadful returns to offence in the Dark Ages (a mere 25% of attackers were victorious) make it obvious why conquests on the scale of Charlemagne (742-814) were so rare. Even generals of extraordinary skill could not avail themselves of the territorial acquisitions needed to requilt the European patchwork of post-Roman principalities. Only with the final period, when political, social, economic, and military affairs all shared a resurgence, does potency of the offence return. For the years 1000 to 1499, 56.9% of attackers emerged victorious. In other words, as Europe and China recovered from the malaise of the medieval era, so too did their armies' ability to conquer territory.

[343] Think, for example, of the retrenchment of Hadrian after the expansions of Trajan.

[344] This deficit is not likely a reflection of any diminishment in the propensity for violence, but rather of the dramatically curtailed ability to record details of the fighting. When civilizations burned, so too did their writing. This provides another assault on Eckhardt's assumption that the only battles to have occurred are those recorded by historians. While we have very little written data on the battles of this time—a reliance on archeological remains will have to suffice—no student of the crumbling of the Western Roman civilization would claim that its replacement was a era of peace and stability. Indeed, just the opposite. The relatively well-recorded *Pax Romana* was replaced by a period of brutal violence, in which the mailed warrior on horseback was merely favoured. That he was illiterate only means the stories of these wars shall likely remain unknown to modern historiography.

Table 3.2 Systemic Technology: -500 to 1500 AD (500 year intervals).

	Total Battles	# of Attacker *Victories*	% of Attacker Success
-500-1	13	10	76.9
0-499	7	4	57.1
500-999	4	1	25.0
1000-1499	58	33	56.9

*All data available in dataset.

The question of whether or not these ages faced varying levels of attacker success for technological reasons—as the theory suggests—or for broader reasons of political, social, and economic decay cannot be settled here. These latter forces can dull military potency just as surely as a shift to defensive weaponry ever could, and therefore pose plausible alternatives to technology theory. But the data available here shed no light on which hypothesis is more compelling. What it does permit, however, is an evaluation of systemic theory's prediction of epochal stability. What we should see in Table 3.2 is a series of attacker success percentages that are either very high or very low, in comparison to the historical mean of 62%. Middling returns, in contrast, suggest that technology did not substantially bias outcomes in either direction. Unfortunately, only two of the four epochs demonstrate a distinct favouring of a specific strategic posture. Both the early imperial and dark ages are clearly biased towards a particular strategic posture (offence and defence, respectively). The other two epochs, however, are far more ambiguous in their results. In both the imperial height and medieval ages, offence is favoured, but only marginally so. The returns to offence in these two cases are less than the aggregate historical average (that is, 62% of attackers emerging victories). This unevenness in the results gives rise to the question of why force posture may be so favoured in some epochs

and not others. In other words, the lack of epochal stability gives reason to suggest that some extraneous variable, operating in conjunction or even *a prior* to the technological condition, is the ultimate causal force. To be certain of this conclusion we must continue to examine the data, particularly against a more narrowed series of epochal comparisons.

1300s to 2006

With the onset of the Renaissance, it becomes both possible and necessary to divide the periods into smaller units of time. Unfortunately, in this second collection of intervals, set 100 years apart, systemic technology theory performs no better. Rather than the predicted series of distinct oscillations between offensive and defensive success, half the cases offer returns to force posture little different than the historical average. The sample begins with two centuries of conditions moderately in favour of the defence. Following this are stronger results in the 1500s, where attackers rode to victory in just 36% of the battles conducted. From there, however, the profitability of offence enters a rather muddled state. No strong departure from the historical mean (and thus indication of clear bias) is thereafter witnessed until attackers earned 66% of victories in the 1900s—a trend which admittedly continues into the 2000s, albeit with an extremely small sample of just eight cases. All of this suggests that technological conditions do not shift decisively, as technology theory predicts.[345] Such findings do not speak well for the predictive power of systemic technology theory.

[345] The results also advance a highly contentious claim. Unlike the mainstream historical literatures, the findings suggest that it was not the 1600s that were a period characterized by defence, but rather the 1500s. It has long been assumed that the age of Vauban's great fortresses was accompanied by frustrated and impotent offense. Louis XIV's struggles against his well-entrenched adversaries provide a case in point. Yet here the results point otherwise, suggesting that modern historiography underestimates Louis XIV's great offensive success which created his empire in the first place. The results thus indicate that a substantial re-evaluation of the era is necessary.

Table 3.3 Systemic Technology: 1300-2006 (attacker win rates, 100 year intervals).

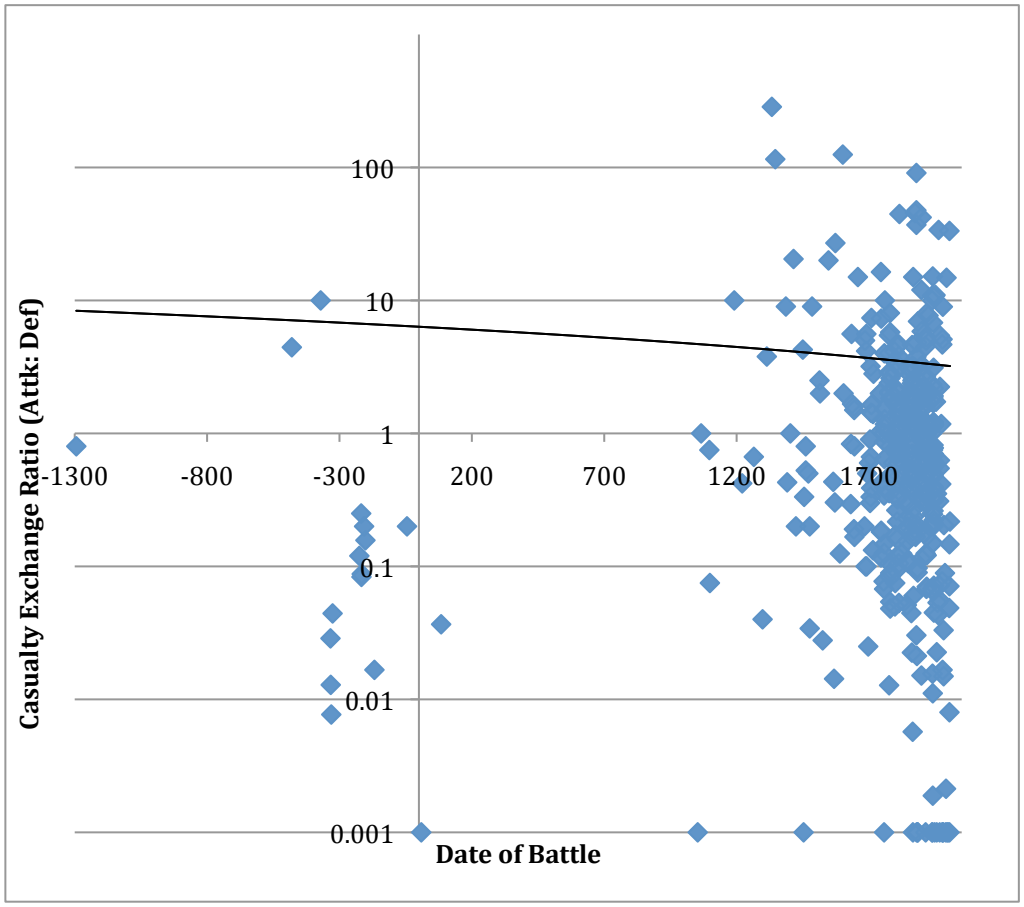
	Total Battles	# of Attacker Victories	% of Attacker Success
1300s	13	7	53.8
1400s	22	12	54.5
1500s	14	5	35.7
1600s	39	23	60.0
1700s	79	48	60.8
1800s	159	95	59.7
1900s	231	153	66.2
2000s	8	6	75

As with dyadic theory, we can further compare systemic theory's assertions against empirical realities by use of a scatterplot. This technique can track attacker-defender performance ratios over time, with the expectation being that the plots should cluster together in any given epoch. For example, in periods where technology favours the attacker, the data plots should cling together for the relevant span of years, relatively high up on the x-axis. In periods where defensive technology reigns supreme, the cluster should sit lower on the y-axis, reflecting the poorer performance (i.e. higher rate of casualties, in comparison to the defender)[346] of attackers during more challenging technological conditions. Every plot above 1.0 line on the y-axis indicates a casualty rate which favours defenders (meaning more attackers were lost than defenders). Those plots under 1.0 indicate a casualty exchange ratio favouring the attacker, with more defenders lost in a given engagement than attackers. What matters most, however, is that

[346] Once again, while the victory or defeat dichotomy would be more a slightly more pertinent dependent variable for the purposes of this study, scatterplots require ratio, not categorical data. Thus the balance in casualties between belligerents is the next best option.

for a given point in time, the plots are consistently clustered together. Whether they are above or below the 1.0 line of equality does not matter to the theory.

Figure 3.3 Systemic Theory Performance: Total (attacker: defender casualty balance, over time).



*Based on 450 battles, ranging from Munda (45 BC) to Lebanon (2006).

Unfortunately for systemic theory, it appears that not much of a pattern exists, let alone crowds of plots at particular points in time. Although the years prior to 0 AD favoured attackers in a relatively uniform manner (a finding consistent with the results in figure 3.2), no others dates show a consistent clustering. From roughly 1300 AD onwards, each point along the x- or chronological axis finds as many battles with casualty exchange rates above the 1.0 line as

below. This means that during any given epoch, an attacker had roughly an equal shot of performing well in battle as performing poorly. Technology therefore does little to 'stack the deck' in favour of one strategic posture or another, as the theory claims. Even the slight trend of recent centuries towards a more consistent favouring of offensive postures does little to suggest that as technology changes, battlefield outcomes are dramatically affected in one direction or the other. Systemic theory only holds true if the evidence can demonstrate a consistent favouring of one posture or the other. Yet history does not show this be to the case.

Alternative Periodizations

Lastly, we can cut the blocks of time into intervals that match with some of the leading periodizations and posture assertions found in the systemic technology literature.[347] By breaking down the attacker success rate data into intervals appropriate to each study, we can get a sense of how these predictions hold up. The method for confirming or disconfirming a prediction will once again rely on the historical average of about a 62% success rate for attacking forces to stand as a basic threshold.[348] Periods presumed to be offensively dominant should therefore see success rates some 5% above that (at least 67%), and those defensively dominant rate about 5% below (no higher than 57%). Figures in the middle are only confirming if the prediction was a 'medium' value, indicating that the impact of technology cuts both ways. A return of 60%, for example, is indicative merely of what is historically common, and thus not decisive in one direction or the other.

[347] For a full elaboration of these predictions, see the appendix tables A.1, A.2, and A.3.
[348] The reason for this is that to use a normal cutoff of 50% would require the sample to be evenly distributed above and below this point. As the 63% aggregate figure suggests, this is not the case.

Table 3.4 Returns to Victory (leading predictions versus actual attacker win rates).

Author	Period	Predicted Balance	Attacker Win Rate (%)	Prediction Correct?
Biddle				
	1900-24	Defensive	58.7	No
	1925-49	Offensive	70.0	Yes
	1950-74	Offensive (very suited)	60.6	No
	1975-00	Defensive	84.4	No
Van Evera[349]				
	Pre-1792	Defensive	59.4	No
	1792-1815	Offensive	60.3	No
	1816-56	Defensive	76.2	No
	1856-71	Medium	60.7	Yes
	1871-90	Defensive	66.7	No
	1890-1918	Defensive	53.3	Yes
	1919-45	Offensive	69.0	Yes
	1945-1990s	Defensive	71.2	No
Adams				
	1800-49	Offensive	65.2	No
	1850-1933	Defensive	57.1	Yes
	1934-45	Offensive	70.9	Yes

*See Biddle, *Military Power*, p23, 251 fn45; Steven van Evera, "Offense, Defense, and War," in Michael E. Brown et al (eds), *Offense, Defense, and War*, (Cambridge, MA: MIT Press, 2004), p246; and Karen Ruth Adams, "Attack and Conquer? International Anarchy and the Offense-Defense-Deterrence Balance," in Brown, *Offense*, p415.

[349] Taken from Van Evera's 'military realities,' as these were the most purely technological predictions.

The results here are not particularly welcome to systemic theory, either. Rather than display a sharp bias in the returns to either offence or defence, the tendency for most periods is for attacker success to however around the 60% mark. Periods of clear posture favouring are few and far between, advancing the conclusion that technology's effects are decidedly ambiguous. Even more disconcerting is that in those periods where decisive effects are felt—that is, attacker success is well above or below the historical norm—the pull is in the wrong direction. Biddle's 1975-2000 period, for example, expects defence to reign supreme.[350] The results, however, show that 84% of all battles in this period were won by the victor. This is precisely the *opposite* outcome our prevailing understanding of the technology of the day expects.

3.4 Conclusions

Chapter Findings

In summary, the evidence collected by this study offers no substantiation of the technologists' claims. Dyadically, the technologically superior have demonstrated only slightly better odds of winning than their rivals. In all but the cases of an extreme technological gap, the chances that the more technologically-endowed will secure victory are little better than even.[351] Overall, the correlation between technological supremacy and battlefield performance is both faint and *negative* in nature. As for systemic theory, the crucial precursor to the theory's verification—epochal stability—has not been met. In only a few of the epochs studied is there a

[350] This is not to say that Biddle himself expects this posture to be favoured, only that this periodization and posture assertion is common in the literature. He is, in fact, a very strong critic of technology theory.
[351] This historical anomaly should be particularly worrisome for Western policy makers, given that the asymmetry of technology between the weak and the strong needed to be massive to ensure victory, the present trend of technology convergence between East and West.

clear tendency for either the offensive or defensive postures to be favoured in battlefield outcomes. Unfortunately, the direction of these biases often disagree with current assumptions regarding which type of technology was most dominant. It is more common is to witness little difference in the rates of success between attackers and defenders. Epochal results tend to hover around a common average, suggesting that technology has minimal direct impact on the success of offensive or defensive strategic postures. Both findings deeply undercut technology theory's claim that technology serves a crucial role in the determination of who wins and who loses.

These results should be somewhat unsurprising, given that there are many reasons to be wary of technological explanations of battlefield victory and defeat. In many cases, technology alone serves as no more than a newfangled nuisance. Gunpowder, for example, did little to help king Edward III's campaign in France.[352] Firearms were similarly ineffective in the comparison to the age-old—but trusted—recurved bow of Asian horse archers until the muskets and field artillery of the early 17th C.[353] In a similar way, the Hellenistic and Imperial Roman knowledge of the simple lever, inclined plane, steelyard, and geometry proved far superior to medieval cannon.[354] After all, the iron and brass 'bombards' of the latter age proved to be "so hard to transport and so slow in firing that the defenders could repair their works between shots."[355] More modern technology, too, suffered from drawbacks. At Roarke's Drift (1879) the metal cartridges of the Martini-Henry breech loading rifles catastrophically expanded as the rifles got hot, forcing the British to rely on their bayonets. By the Great War gunpowder weapons had

[352] Knox and Murray, *Dynamics of Military Revolutions*, p22.
[353] Parker, *Warfare*, p1. Early hand guns were so clumsy that in "close combat they could serve only as clubs." Nef, *Progress*, p29.
[354] Nef, *Progress*, p28. Hans Delbrück suggests that firearms had no serious influence on battle outcomes until the last quarter of the 15th century. Delbrück, *Geschichte der Kriegskunst im Rahmen der Politischen Geschichte,* (Berlin, 1907), III, p669. Meanwhile, even as late as the early 1800s, battles "were still to be decided by the push of pike—now bayonet charge—at the decisive moment. At Borodino (1812—one of the bloodiest battles of the Napoleonic period) the average French infantryman used only ten rounds of ammunition." Ropp, *War*, p47.
[355] Ropp, *War*, p25.

become far more capable, yet they were still no more useful. Military commanders such as Falkenhayn, Joffre, and Haig boasted in their armies explosive potential undreamt of by previous generals. But all this unprecedented technology translated into few tangible gains in the mud of Flanders, Champagne, and the Artois.[356] Even as nations devoted ever more resources to military innovation and shell production, the result was nothing more than prolonged, brutal stalemate. Neither Zeppelins nor tanks nor submarines proved to be the missing technology needed to bring the war to a victorious conclusion.

Technological advantages are also fleeting. Blueprints can be copied and working models reverse-engineered. This generally ensures a degree of rough symmetry between armies. Genghis Khan's march through northern China, for example, relied on Chinese siege engines he commandeered along the way.[357] Ideas alone can circulate and inspire technological mimicry. Take how quickly the idea of the all big-gunned battleship spread like wildfire through Europe immediately after HMS *Dreadnought* was launched. Details of Admiral Fisher's project crossed borders easily, and soon the French, German, Russian, and Japanese navies were putting to sea their own versions of this revolutionary development.[358] Technology can also be purchased, even by those with limited means. Often overlooked is that the Sudanese employed machine guns at Omdurman (1898) as well.[359] Perpetual European rearmament ensured that Africa faced a steady supply of rifle imports.[360] Today, the Taliban hail from some of the most impoverished villages on the planet. But they are also incredibly internet-savvy and deploy heat-seeking

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[356] As John Keegan has trenchantly observed, artillery as an offensive force is severely limited without the mobile telephone. Lacking this means of communication, commanders could not keep pace with the advance. See his *The First World War*, (Vintage, 2000), p312-314.
[357] This is a particularly crucial theoretical problem for dyadic theory: one can always just copy one's opponent's weapons.
[358] See, for example, Robert K. Massie, *Dreadnought: Britain, Germany, and the Coming of the Great War*, (New York: Random House, 1991); and Peter Padfield, *The Great Naval Race: The Anglo-German Naval Rivalry, 1900-1914*, (New York: D. McKay, 1974).
[359] The Dervish leader, Al-Taashi, employed two. Ferguson, *Cash Nexus*, (New York: Basic Books, 2001), p438.
[360] See Headrick, *Tools*, p105-14.

missiles.[361] Moreover, even the most sophisticated of technology can be mitigated by relatively simple means. In the Middle East, Israel's marked regional superiority in tanks and airplanes has in the past been blunted by the proliferation of portable and relatively cheap anti-tank and anti-aircraft missiles.[362] Similarly, America's vast air superiority in Vietnam was muted by the NVA's embrace of caves, bicycles, and jungle trails.[363] Today Taliban fighters find sensor-defying cover in terrain as diverse as mountain caves, irrigation ditches, and urban sprawl.[364] For every technology that has been invented, so too have there been measures developed to counter, evade, and offset its effects.[365] The technological advantages that wealth provides therefore have a tendency to diminish over time, evening the gap between belligerents.

Even when technology affects battlefield performance, the actual implications can be deeply misinterpreted. It is difficult to prove the proper utility of a new weapon without using it in a major war. For this reason, a "new technology will normally be assimilated to an old doctrine rather than stimulate change to a new one."[366] Worse, even those cases where new weapons are put into practice can be deeply misunderstood as well. The commanders of 1914, for example, would not have been so surprised at the failure of all the major offensive plans that fateful summer—Germany's Schlieffen Plan, France's Plan XIV, Russia's Plan 19, and so on—

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[361] C. J. Chivers, Carlotta Gall, Andrew W. Lehren, Mark Mazzetti, Jane Perlez, and Eric Schmitt, with contributions from Jacob Harris and Alan McLean, "View Is Bleaker Than Official Portrayal of War in Afghanistan," *New York Times*, (July 25, 2010).

[362] In December 2010, militants in Gaza penetrated the armour of an Israeli tank with a Russian Kornet missile. In the 2008 Lebanon War, Hezbollah was able to destroy or disable three dozen Israeli tanks through similar means, roughly 10% of the total deployed. Dan Williams, "Israel sees new anti-tank missile threat from Gaza," *Reuters*, (December 21, 2010).

[363] And while billions of dollars spent on electronic countermeasures again North Vietnamese antiaircraft radars, more US planes were being damaged or destroyed in ground attacks on poorly protected air bases than were shot down by Soviet-supplied SAMs. Alic, *Trillions*, p21.

[364] Stephen Biddle, "Iraq, Afghanistan, and American Military Transformation," in John Baylis, James J. Wirtz, and Colin S. Gray (eds), *Strategy in the Contemporary World: An Introduction to Strategic Studies*, (Oxford: Oxford University Press, 2009), p268-70.

[365] As Colin Gray notes, victory is possible with inferior technology so long as it exists within a "compensatable range." Gray, *Another Bloody Century*, p123.

[366] Posen, *Doctrines*, p55.

if they paid closer attention to the developments of the previous half century. The high cost of offensive action in the US Civil War (1861-65), the Russo-Turkish War of 1877, and the Boer War (1899-1901) should have carried a clear message: attack over open ground is murderously risky in the age of shell, bullet, and barbed wire.[367] But the lesson did not stick. On the contrary, it appears that the only sure way to learn the appropriate lessons of changing technology is to suffer from its effects firsthand—and even then, the instructions can be slow to take.[368]

Technology as False Idol

So much, then, for the supremacy of technology. In fact, history is replete with examples where the promise of technology has failed to deliver. Foremost is the growth in firepower witnessed in recent centuries. The 20th century in particular saw the endless tinkering and development of shells, bullets, and bombs. The consequence of this applied ingenuity is that the lethality of these death-dealing instruments has grown at incredible rates. The range and net penetrativity of crew-served weapons, for example, has grown by more than a factor of 10 between 1900 and 1990.[369] Such tremendous killing potential would seem to empower whoever used these weapons, whether they be attackers or defenders, with the consequence being devastation for their opponents. Yet average casualty rates over this same period have fallen by more than 60%, indicating that the deadly promise of these new technologies is not being realized.[370] The concept of mobility has endured similarly paradoxical results. Between 1900

[367] See fn #46 in Posen, *Doctrine*, p55.
[368] The debacle that was Prussia's railroad mobilization against Austria in 1850, for example, provided the impetus for improvement that led to the smoothly operating marching against Austria in 1866, and then France in 1870. See fn #47 in Posen, *Doctrines*, p56. Learning does not happen equally, though. Posen notes that in the American Civil War, "frontline soldiers adjusted rapidly to the technological fact of modern firepower. They 'dug in' whenever they had the chance." In contrast, the "generals understood the least, ordering frontal assaults against prepared positions throughout the war." Posen, fn #48 in *Doctrines*, p56.
[369] Stephen Biddle, "Past as Prologue: Assessing Theories of Future Warfare," *Security Studies*, 8, 1 (Fall 1998), p13-14.
[370] Biddle, *Military Power*, p23, 251 fn 44. Values obtained from OLS regression on COW data.

and 1990 an army's weapon platform's nominal speed increased by more than a factor of 10, yet a typical army's average rate of advance remained virtually constant at levels little changed since Napoleon's day.[371] For all of the potency developed in the last 100 years, it appears that armies cannot take advantage. The effects of technology, then, are not so simple to uncover as technology theory presumes.

Another, more specific, example reinforces the point. As the world stood on the precipice of war in 1914, the French 75mm gun, the 'Fabulous 75', was the finest fieldpiece in the world. It was uniquely mobile and accurate, and possessed the ability to fire an incredible 15-20 rounds per minute. Yet for all its magnificence, it was "too good; it helped mislead the French to unwarranted confidence in a short war of movement. [Thus] Obsessed with its merits, the French expected all things of the '75' and failed to balance their artillery with the howitzers and heavy pieces needed for the kind of war that actually ensued."[372] The consequence was that the French lacked the 105mm and heavier guns that the German army employed in abundance. As those hot days in August wore into the panicked frenzy of September—and the gloomy years of stalemate thereafter—the French army would learn that even the finest technology requires not only an amenable time and place, but also integration into a larger tactical and strategic

[371] In 1815 the rate of advance for a lightly engaged infantry soldier was, on average, 19.5km per day. As of the mid-1960s, a lightly engaged mechanized trooper could expect to average just 21.2km per day. Heavily engaged forces could expect to fare better, but only marginally so; 150 years of technological change induced an improvement in the average pace of just a factor of two (1.7km for heavily engaged infantry per day in 1815, 3.7km per day for heavily engaged mechanized forces in the mid-1960s). Robert Helmbold, *Rates of Advance in Historical Land Combat Operations*, CAA-RP-90-1, (Bethesda: U.S. Army CAA, 1990), p4-9 to 4-10. "This relative stasis in spite of major increases in platform speed has produced a yawning gap between modern weapons' nominal mobility and their average battlefield performance: in the late twentieth century, weapons' nominal speeds typically differed from realized rates of advance by factors of 30 to 100. Tanks from the 1970s able to drive 30-40 kilometers per *hour* on the proving ground, for example, averaged less than 4 kilometers per *day* in combat against significant opposition." Biddle, *Military Power*, p250-1, fn #42, citing ibid.

[372] William G. Dooly, Jr., *Great Weapons of World War I*, (New York: Bonanza Books, 19XX).

system that can take advantage of the capabilities the weapon offers. In a long and bloody lesson,[373] the French would discover that technology is no panacea.

What the French army learned is that technology cannot be separated from nonmaterial factors, such as leadership, tactics, and training. As Colin Gray has observed, "the engines of war can perform no better than the people who must direct them."[374] Thus while the sophistication of weaponry has advanced relentlessly, so too have the doctrinal responses capable of blunting the effects of this technological change. Most crucially, as weapons became more deadly, battlefields became more dispersed.[375] Compared to antiquity, the lethality of a modern army, 100,000 soldiers strong, has increased roughly 2,000-fold.[376] Similarly, whereas the average Prussian cannon fired just under 200 rounds during von Moltke the Elder's five month campaign in 1870-1, the 1,000 rounds per barrel his nephew went to war in 1914 with sufficed for no more than 6-8 weeks. By 1918, batteries were firing as many as 450 rounds per *day*.[377] Yet for all this advance in destructive capacity, dispersion has increased even more, by a factor of roughly 5,000.[378] Whereas an army 100,000-strong in antiquity took up the space of just $1km^2$, a similarly-sized army in the 1973 Arab-Israel War required $3{,}500km^2$.[379] Put another way, the force-to-space ratio of a Greek phalanx was one hoplite per square meter. In contrast, soldiers of the 18thC—though still standing shoulder to shoulder—fought in armies dispersed to the point that the ratio was now one soldier every 10m. As time progressed, so did the space an army took. By the US Civil War, the last war fought largely with muzzleloaders, the ratio was

[373] For the trauma inflicted on France in the Great War, see Robert A. Doughty, *Pyrrhic Victory: French Strategy and Operations in the Great War*, (Cambridge, MA: Belknap Press, 2005).
[374] Gray, *Another Bloody Century*, p102.
[375] See Trevor N. Dupuy, *Attrition: Forecasting Battle Casualties and Equipment Losses in Modern War*, (Falls Church: Nova Publications, 1995), p25-31.
[376] Dupuy, *Attrition*, p29.
[377] Creveld, *Technology and War*, p175.
[378] Dupuy, *Attrition*, p29.
[379] Dupuy, *Attrition*, p26.

1:25. The Great War obliterated that record, reaching 1:250, a figure which itself was replaced by one several times that in its 1939-45 sequel.[380] Another measure of troop dispersion is to compare the distance between the two wings of an army. Traditionally, the left and right have advanced about 5-6km apart. By the time of Napoleon, however, this distance reached 25-75km.[381] By World War II, hardly more than a century later, this distance had ballooned even further, to literally hundreds of kilometers. Thus while technology changed, so too did the tactics needed to defeat it. Indeed, the best way for an army to survive an ever more intense 'storm of steel' is to spread out and pose a less concentrated target.

In this way, tactics can be seen to have overshadowed technology. Dispersion has, after all, outstripped lethality, with the consequence being a consistent drop in daily casualty rates over time. Take how both victor and vanquished could expect to lose 20% or more of their force in the time of Gustavus Adolphus and the Thirty Years War (1618-48). This figure had fallen by half by the Mexican War of 1848, and then was halved again during World War I. Following World War II, even the poorly-performing Egyptian army lost no more than 3% per day in its wars against Israel. Although the mechanical capability of weapons improved, their effectiveness on the battlefield diminished.

This is not to suggest that technology is without importance. The celebrated chemist Robert Boyle was not wrong to suggest "the invention of gunpowder hath quite altered the condition of martial affairs over the world, both by sea and land."[382] By handing laymen the ability to strike generals dead at 1,000 yards, for example, the Paris Communards became

[380] Creveld, *Technology and War*, p173.
[381] Creveld, *Technology and War*, p170-1. Napoleon actually advanced in Russia with his wings at a greater distance apart, but he eventually lost effective control of his *Grande Armée*.
[382] Robert Boyle, "Of the Usefulnes of Natural Philosophy," *Works*, (London, 1772), II, p65.

convinced that "the rifle made all men tall."[383] Yet technology in and of itself is no more than inanimate material; a giant's hands are useless without a brain. The point here is that while technology matters a great deal, it serves as merely an intervening variable. Technology is not the ultimate cause of battlefield victory and defeat. What matters instead is how well tactics are formulated and implemented in response to technological progress. The Swiss pike, for example, would have been useless without formation discipline and a suite of tactical commands to go along with it. In the same vein, Germany's military equipment was generally outclassed by its opponents in 1940. This did not, however, rescue the Franco-Anglo entente, as the allies were overwhelmed by an opponent that knew how to fight a modern combined arms war, while the Allies themselves most certainly did not. Even more noteworthy is that while the technology of 1918 was not profoundly different than that of 1916, the efficacy of its use—the development of "the modern style of warfare"—had undergone a monumental revolution.[384] Tactics made possible what technology could not.

Technologists therefore get the point of technology wrong. The matter is not about weapons technology itself, nor whether a weapon's characteristics are more amenable to an offensive or defensive strategic posture. Instead, victory is achieved by using weapons to inflict casualties on an enemy, while simultaneously avoiding similar weapons inflicting the same degree of losses on you in return. The utility of any technology therefore relies not on its ever-increasing capacity to kill, but rather how well these devices have been integrated with operational ability, effective doctrines, and strategic plans. "[M]achines do not win battles, even

[383] Thomas Carlyle, cited in John Keegan, *The Second World War*, (Penguin, 2005), p23.
[384] Jonathan Bailey, cited in Gray, *Bloody*, p22. As Knox and Murray observe, a British or German battalion commander magically transported from 1914 to 1918 would recognize most weapons, but have a tough time understanding the underlying concepts governing warfare. *Dynamics*, p10-1. In contrast, a battalion commander from 1918 sent to 1940, 1944, or even 1991 would appreciate the emphasis on infiltration, suppression, and combined arms movement.

if battles are won with machines - a very great difference."[385] Technology is merely a lever to amplify (or diminish) underlying material, institutional, and intellectual resources. In short, it is not technology itself that matters, but instead the proficiency of its use. The lesson, as the great Jomini advises us, is that while "The superiority of armament may increase the chances of success in war, but it does not of itself win battles."[386] This should stand as a strong caution to anyone who relies on technology to deliver victory.

[385] Knox and Murray, *Dynamics*, p193. Perhaps this infatuation with military technology, particularly combat platforms, is because "long-range bombers, major surface vessels, and main battle tanks, are far easier to count and assess in prospective action, than are such intangibles as training, morale, organization, doctrine, and quality of leadership." Gray, *Another Bloody Century*, p98.
[386] Cited in Parker, *Warfare*, p2.

Chapter 4: Testing Proficiency Theory

Of Talent and Triumph

Assessing the Relationship Between Combat Proficiency and Battlefield Victory

"It is not big armies that win battles, it is the good ones!" – **Maurice de Saxe** (1757)[387]

"Victory in war does not depend entirely on numbers or courage; only skill and discipline will ensure it." **Flavius Vegetius** (A.D. 378)[388]

Abstract

Proficiency theory asserts that battles are won by belligerents more adept at fighting than their opponents. This combat capability is most straightforwardly measured by relative loss ratios: the more casualties inflicted on an opponent per each loss incurred in turn, the more capable we can infer that army to be. While this is an admittedly *post facto* measurement—the final distribution of casualties is only known after battle is

[387] Maurice de Saxe, *Mes reveries*, (*Economica*, 2002 [1757]). See also Saxe, *Reveries or Memoirs upon the Art of War*, with W. Fawcett (trans), (London: 1757).
[388] Cited in William Martel, *Victory in War*, (Cambridge University Press, 2006), p161.

completed—loss ratios nevertheless are the clearest expression of an army's fighting ability. Indeed, military capability is ultimately a matter of being able to inflict more casualties upon the enemy than one endures in return. Blunderers may win battles, but they cannot be expected to outperform the nimble. Moreover, loss ratios permit a systematic evaluation of the relationship between superior combat performance and victory over long periods of time. To this end, the results of 395 battles, ranging from Kadesh (1274 BC) to Kuwait (1991), suggest that the more proficient have emerged victorious roughly 80% of the time. Skill is therefore a powerful predictor of military success. The caveat, however, is that discrepancies in combat effectiveness can be overcome with sheer numbers, at least when the qualitatively inferior belligerent is three times larger. As the battle of Wanat (2008) has recently demonstrated, even the most capable of armies must be wary of this fact.

The most unsung explanation for battlefield victory and defeat is proficiency theory.[389] Here the concern is less on material factors and more the confluence of tactics, training, motivation, and the effective deployment of field forces.[390] It is, in short, the argument that

[389] Others describe theories of combat capability and victory as matters of 'force employment' or 'force posture', but to the author this fails to incorporate the other factors that are so important to relative fighting ability. 'Proficiency' is a much more inclusive term. Among the scarce (political science) writings in this school are Mearsheimer's "attrition-blitzkrieg" strategic dichotomy to explain conventional deterrence, Stam *et al*'s similar "attrition-maneuver-punishment" schema to address war duration, victory, and defeat, and Biddle's "modern system" as explanation for the difference between decisive breakthrough and bloody stalemate on the modern battlefield. See also Colin Gray, *Modern Strategy*, (Oxford University Press, 1999); John Mearsheimer, *Conventional Deterrence*, (Ithaca: Cornell University Press, 1993); Alan Stam, *Win, Lose or Draw* (Ann Arbor: University of Michigan Pres, 1996); D. Scott Bennett and Allan Stam, "The Duration of Interstate Wars, 1816-1985," *American Political Science Review*, 90, 2 (1996), p239-57; Dan Reiter and Allan Stam, "Democracy and Battlefield Military Effectiveness," *Journal of Conflict Resolution*, 42-3 (June 1998), p259-77; Biddle, *Modern*, p28-51 (formal model p209-239). Of course there exist innumerable historical works on the importance of strategy and tactics (B.H. Liddell Hart's *Strategy*, David Chandler's *The Art of Warfare on Land*, and John Keegan's *A History of War* standing as just a brief sample), but these are not works of theory. Instead they are richly detailed descriptions of the *art* of war, and thus sit outside the realm of this paper.

[390] Niall Ferguson, for example, notes that economic inferiority can be overcome with superior strategy, operations,

victory is ceded to the belligerent more militarily competent than its opponent, regardless of the numbers or even technologies involved.[391] Such importance is ascribed to superior combat performance because technology can be confounded and superior numbers outmaneuvered. As the Prussian general von Bernhardi notes,

> "superior numbers under otherwise equal conditions should guarantee us victory at least in theory. Yet military history proves that it is not simply superior numbers that achieve victory but how those numbers are used and how war is conducted."[392] The Romans, after all, "conquered the world with inferior numbers."[393]

Nor do such laurels stop with the Romans. Frederick the Great, for example, would frequently defeat enemies nearly twice his size. More recently, the 1948 War for Independence saw victorious Israel outnumbered by its Arab rivals an incredible 33:1.[394] Technology, too, can be offset by clever tactics and gifted generalship. "Competent irregular enemies, in particular, are reluctant to present themselves as lucrative target sets to be pulverized from the air, or to be outmaneuvered for annihilation."[395] The army of Vo Nguyen Giap, for example, profited from his reluctance to meet the Americans in open battle, always managing to survive for another day. So too can even the most modern armies be confounded. Witness the strategic debacle at Bagration (1944), where the wholesale destruction of Army Group Centre belied Germany's technological superiority over the Soviets. Even the combination of superior numbers and

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tactics, morale, and mobilization, at least in the short run. Ferguson, *Cash Nexus*, (New York: Basic Books, 2002), p400.

[391] John Arquilla, *Dubious Battles*, (Taylor & Francis, 1992), p55. More formally, Arquilla suggests that "military 'skill' [is] hypothesized to outweigh in importance any of the more quantitative measures of 'strength.'" John Arquilla, *Dubious Battles*, p10.

[392] Friedrich von Bernhardi, *On War of To-day*, vol. I: *Principles and Elements of Modern War*, Karl von Donat (trans), (London: Hugh Rees, Ltd., 1912), p89.

[393] von Bernhardi, *On War*, p85.

[394] As Arquilla notes, "If the ratio is figured on the basis of opposing field armies, the Arab advantage grows to 39:1." Arquilla, *Dubious Battles*, p54, 69 fn #12.

[395] Gray, *Another Bloody Century*, p111.

technology can prove insufficient to keep a gifted army at bay. The Mongols left the steppes with both smaller forces and less sophisticated weaponry than the European armies who met them, yet the hard-charging *hordes* dispatched all opponents with relative ease.[396] Indeed, the Mongol army was a near-perfect expression of how individual courage and skill, tactical organization and innovation, and supreme strategic genius can combine to form a virtually irresistible foe.[397]

Materialist explanations for battlefield victory are therefore insufficient. Victory is not simply a matter of the number of troops and how good their weapons are, but rather a reflection of how well military forces put these material underpinnings, through tactics and strategy, to good effect. As such, it is worth considering the role troop performance has played in victory over time. In other words, does victory go to the more proficient? To answer this question we move first to a discussion of the foundations of proficiency theory, followed by an examination of the historical evidence.

4.1 Literature Review: Proficiency Theory

Barriers to a Theory of Proficiency

The argument that superior combat capability will prevail in battle has been voiced since early times. The great Roman writer Flavius Vegetius Renatus, for example, tells us that "Victory in war does not depend entirely upon numbers or mere courage; only skill and

[396] *Horde* is the Mongol term for 'army.' Given the unprecedented success of the Genghis and his generals, Western Europeans could not believe that in virtually all the major engagements of this time, the Mongols fought as the numerical inferior. Horde was therefore bastardized in the West to mean teeming, undisciplined masses—when of course nothing could have been further from the truth. See, for example, Peter Jackson, *The Mongols and the West: 1221-1410*, (Longman, 2005); along with J.J. Saunders, *The History of the Mongol Conquests*, (University of Pennsylvania Press, 2001); and Angus Stewart, *The Mongol Empire*, (Continuum, 2011).
[397] Timothy May, *The Mongol Art of War*, (Westholme, 2007).

discipline will insure it."[398] More than a millennium later, British military officer E.A. Altham concurred, arguing that "victory or defeat depends not so much on the size of armies and fleets as on their fighting efficiency."[399] Even the great Clausewitz, a scholar much taken with ideas regarding numerical preponderance and the need for material supremacy, suggests a role for proficiency as well. The "surest way to victory," he wrote, is to conduct "engagement[s] with the greatest economy of force" and to position one's army to make the "most of the moral effect of strong reserves."[400] It takes great skill, after all, to ensure one's reserves are deployed at the precise point the enemy's have been exhausted. Thus tactical agility is seen here as the most certain basis for military triumph.

Despite this substantial legacy, proficiency theory faces muted popularity within modern political science. In contrast to the theories of preponderance and technology, proficiency is rarely studied. In the great postwar texts of international relations theory, for example, strategy—which is one of the crucial wellsprings of combat performance—hardly rates a mention.[401] This is largely a reflection of the materialist nature of the structural theories that bulk so large in the contemporary literature. According to these theories, "states make optimizing choices guided chiefly by material constraints."[402] As a consequence, no allowance is made for individual or institutional choice. Outcomes, too, are seen as determined by material balances rather than troop performance. Thus not only will the "distribution of power…heavily determine when fighting occurs," but also "who will side with whom, and who will win."[403] In this light, military conflict is seen as no more than a series of "grinding, attritional struggles, with

[398] Vegetius, *De re militari*, 13. See Martel, *Foundations*, p21-22; and Alger, *Quest*, p5-6.
[399] E.A. Altham, *The Principles of War, Historically Illustrated*, (London: Macmillan, 1914), p35.
[400] Clausewitz, *On War*, Matthjijis, p190. See also Martel, *Foundations*, p35.
[401] Morgenthau and Knorr, for example, only make brief mention of strategy. Hans Morgenthau, *Politics Among Nations*, 6th ed (New York: McGraw Hill, 1985), p141-42; Klaus Knorr, *Military Power and Potential*, (Lexington: D.C. Heath, 1970), p119-36; Waltz, *Theory of International Politics*.
[402] Biddle, *Military Power*, fn 32, p249.
[403] John Arquilla, *Dubious Battles*, (Washington: Crane Russak, 1992), p10.

both sides earning victories and defeats." In the end, the final outcome is the "result of cumulative gains made and losses incurred, added up on some 'cosmic toteboard.'"[404] Generalship and soldiery are therefore seen by the materialists as playing no role in the determination of military outcomes.

Given political science's preference for structural theories, it is unsurprising that the mantle of battlefield performance has been most eagerly taken up by the discipline that recoils from the materialist thought espoused by Morgenthau and his realist disciples: history. Indeed, the majority of proficiency writing has been done by historians, for they care about the context and nuance that mainstream, positivist political science so often ignores. Historians stress the qualitative and the contextual over the quantitative and the universalized. In so doing, historians have illuminated the importance of leadership,[405] tactics,[406] training,[407] logistics,[408] adopting appropriate technology,[409] the importance of war plans,[410] even the relevance of socio-political factors to battlefield performance.[411] This work has done much to shape our appreciation of the role non-material factors can play in battlefield outcomes.

The problem, however, is that these works tend to stick to context-specific explanations, rather than working to uncover generalizable patterns. This is because historians contend such patterns are almost impossible to unveil. Some suggest they hardly exist at all. According to Sir

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[404] Arquilla, *Dubious Battles*, p24.
[405] See Chandler, *Napoleon*, (Littlehampton, 1974); also Telford Taylor, *Sword and Swastika: Generals and Nazis in the Third Reich*, (Chicago: Quadrangle Paperbacks, 1952).
[406] Paddy Griffith, *Battle Tactics of the Western Front*, (London, 1992); and Major General F.W. von Mellenthin, *Panzer Battles: A Study of the Employment of Armour in the Second World War*, (Old Saybrook, CT: Konecky & Konecky, 1956).
[407] Martin van Creveld, *Fighting Power: German and US Army Performance, 1939-45*, (London: Arms and Armour Press, 1983).
[408] Martin van Creveld, *Supplying War*, (Cambridge: Cambridge University Press, 1977).
[409] Bill Rawling, *Surviving Trench Warfare: Technology and the Canadian Corps, 1914-1918*, (Toronto: University of Toronto Press, 1992).
[410] Gerhard Ritter, *The Schlieffen Plan*, (New York, 1959). Keegan has argued that "it is perhaps the single most important book ever published on the First World War." John Keegan, *The First World War*, p451.
[411] Victor David Hanson, *Why the West Has Won*, (London: Faber and Faber, 2001).

Charles Oman, "The human record is illogical...and history is a series of happenings with no inevitability about it."[412] Even amongst more moderate views, the consequence of an emphasis on particularized circumstances is that historians do not care much for models and predictions.[413] To historians, the conditions of one epoch are usually seen as separate and distinct than those from another, thus any conclusions drawn from the former are not directly applicable to the latter. Systemizations such as those of Toynbee[414] are thus exceedingly rare in the discipline of history, and prognostications are rather curtly admonished. In the words of J.R. Roberts, "Historians should never prophesy."[415]

As understandable as this call for humility may be, prognostication is a business that cannot be avoided. This is particularly so in matters of war, for the risks and rewards associated with violence demand deep consideration of the prospects for victory. Prudence compels policymakers to consider which battles they are likely to win—and those that they are better off conceding. Crucially, these conclusions are predicated on the same causal inferences that historians so dutifully avoid. The results of previous engagements are invariably used to anticipate the outcome of future contests, even if done so only on an *ad hoc* or intuitive basis. Best, then, to ensure these considerations are instead made with the most rigorous and systematic understanding of the central tendencies underlining battlefield outcomes as possible. While any 'scientific' theory of proficiency will inevitably be imperfect, such efforts are a vast improvement over a sole reliance on mere impressions and hunches.

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[412] Cited from Barbara Tuchman, *Practicing History*, (New York: Knopf, 1981), p22.
[413] See, for example, Pierre Renouvin and Jean-Baptiste Duroselle, *Introduction to the History of International Relations*, Trans. Mary Ilford, (New York: Frederick A. Praeger, 1967), p376.

[414] Arnold J. Toynbee; and D.C. Somervell (ed), *A Study of History: Abridgement of Volumes I-VI*, (Oxford University Press, 1987).
[415] Roberts, *World History*, (Penguin), pxii.

This is not to say that the obstacles in front of a theory of proficiency are insignificant. Two obstacles in particular make proficiency difficult to model. First are the problems associated with the "relativity of strategy."[416] Addington warns that "Although there may be a 'science' for waging war in a particular era and culture, it seems to me that no 'principles of war', save those that are reducible to common sense, have ever existed independent of time and circumstance."[417] Arriving at a universal explanation of victory and defeat is impossible, given that the utility of particular strategies and tactics vary according to the political, social, and economic contexts of the age. To be more specific, according to the German historian Delbrück, there are two main strategies of war: annihilation and attrition.[418] The former aims to defeat an opponent decisively on the battlefield. Alexander, Caesar, and Napoleon all employed this strategy to devastating effect, predicating their great victories on colossal battles of concentrated savagery. In contrast, the latter strategy seeks to weaken an enemy through steady accumulation of losses. This is a starkly different method, yet one utilized to similar success by Pericles and Frederick the Great.[419] The lesson is that both strategies[420]—adopted amongst vastly different material circumstances—paid handsome dividends, leading Delbrück to conclude that there is "no justification for the belief that there is a unified theory of war that applies equally to all historical periods."[421]

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[416] See Martel, *Foundations*, p48.
[417] Larry H. Addington, *The Patterns of War Through the Eighteenth Century*, (Bloomington: University of Indiana Press, 1990), pxi.
[418] Gordon A. Craig, "Delbrück: The Military Historian," in Earle, (ed), *Makers of Modern Strategy: Military Thought*, p273.
[419] Craig, "Delbrück," p273.
[420] Another useful strategic dichotomy is Chaliand's assertion that the two chief strategies in history have been the attack, retreat, and envelopment, as practiced by the nomads in Central Asia & Arabs, and by charging in line to create a breech, such as those tactics adopted by the Greek phalanx, Roman legion, and Frankish *leudes* ('old soldiers). Chaliand, *The Art of War in World History*, p20. As for tactical matters, Knox and Murray describe the operational debate as yet another dualism, where the two contending views are maneuver supported by firepower, and firepower supported by maneuver. Knox and Murray, *Dynamics*, p153.
[421] Martel, *Foundations*, p48. See also Craig, "Delbrück," p273. Craig elaborates that in "the Peloponnesian War, the political weakness of Athens in comparison with that of the League which faced her, determined the kind of

To this extent, Delbrück was correct. The quest for a 'Grand Unified Theory' that has so driven the efforts of physicists from Einstein onwards cannot be replicated here.[422] The potential permutations of tactics and strategies are surely as numerable as the circumstances within which an army finds itself. What worked for Napoleon at Wagram may not have been an option for Petraeus in Helmand. This does not, however, preclude a systematic examination of battle performance over time. Insofar as the needs of proficiency theory are concerned, neither Napoleon's affinity for battles of annihilation nor NATO's Afghan reality of steady attrition are important. Instead, the central concern of proficiency theory is whether each army *outperformed* its rivals, and whether or not this led to victory on the battlefield. More formally, the independent variable is superior performance, and the dependent variable is victory. It therefore matters little which specific strategy was adopted—be it annihilation or attrition—but rather how suitable it was for the conditions of the day. Both annihilation and attrition are done well when a belligerent kills more of their opponent than the casualties they endure in return.[423] In this way, even absent a universality of strategy and tactics, we can still measure relative performance over time and compare its relationship to victory.

The second obstacle to modeling proficiency is the fact that there are many causal paths that lead to superior performance. Alexander's strategic genius and insatiable lust for conquest, for example, underpinned the Graeco-Macedon rampage through South Asia.[424] In contrast, Britain's endless stream of imperial victories are better associated not with brilliant

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strategy which Pericles followed. Had he attempted to follow the principles of [annihilation,] disaster would have followed automatically." p274.

[422] See, for example, Takeshi Fukuyama and Tatsuru Kikuchi (eds), *Grand Unified Theories: Current Status and Future Prospects: An International Workshop*, (American Institute of Physics, 2008); Chaul Ryu, *The Grand Unified Theory: A Scientific Theory of Everything*, (PublishAmerica, 2004); and Brian Greene, *The Elegant Universe: Superstrings, Hidden Dimensions, and the Quest for the Ultimate Theory*, (Vintage, 2000).

[423] My thanks to Brian Bow for this point.

[424] See Philip Freeman, *Alexander the Great*, (Simon & Schuster, 2011); and Waldemar Heckel and J.C. Yardley (eds), *Alexander the Great: Historical Sources in Translation*, (Wiley-Blackwell, 2003).

generalship—of which there were strikingly few examples between Marlborough and Slim—but of a hardened, well-experienced NCO corps, able to grind out victory even when haphazardly commanded. Even amidst common circumstances, armies can display proficiency for vastly different reasons. During the Crusades, Byzantium's armies were sustained by unsurpassed efficiency in military organization, a gift that kept the Anatolian heartland intact for 1,000 years after the Roman fall, despite dramatically more numerous neighbours. The Byzantines' western European rivals, however, relied on overwhelming strength in heavy cavalry (at least when properly used, such as at Arsuf in 1191), while the Muslim armies of the day relied on mobile armies of light cavalry who appeared immune to heavy casualties.[425] The lesson of these varied sources of combat power is that the roots of military proficiency run tangled and deep.

We need not despair, however, for all these various roots of military strength combine to form an aggregate capability.[426] Proficient armies—whatever their basis of power—are united by their ability to outperform rivals. True, the reasons for this superior performance can vary greatly from one army and one epoch to the next. "A fully effective military," for example,

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[425] See, for example, Timothy Gregory, *A History of Byzantium*, (Wiley-Blackwell, 2005); Hugh Kennedy, *The Prophet and the Age of the Caliphates: The Islamic Near East from the 6th to the 11th Century*, (Longman, 2004); and Jonathan Phillips, *Holy Warriors: A Modern History of the Crusades*, (Random House, 2010).

[426] See Klaus Knorr, *Military Power and Potential*, (Cambridge: D.C. Heath, 1970); Martin van Creveld, *Fighting Power* (Westport Greenwood, 1982); Trevor N. Dupuy, *Numbers, Predictions, and War*, rev. ed. (Fairfax: Hero, 1985); Allan Millett and Williamson Murray, eds., *Military Effectiveness*, 3 vols. (Boston: Allen and Unwin, 1988); Charles Kupchan, "Setting Conventional Force Requirements," *World Politics* 41, no. 4 (July 1989): 536-78; Steven Miller, ed. *Conventional Forces and American Defense Policy* (Princeton: Princeton University Press, 1986); Joshua Epstein, "Dynamic Analysis and the Conventional Balance in Europe," *International Security* 12, no. 4 (Spring 1988): 154-65; John Mearsheimer, "Numbers, Strategy, and the European Balance," *International Security* 12, no. 4 (Spring 1988): 174-85; John Mearsheimer, "Assessing the Conventional Balance: The 3:1 Rule and its Critics," *International Security* 13 (Spring 1989): 54-89; Barry Posen, *Inadvertent Escalation* (Ithaca: Cornell University Press, 1991); Elliot Cohen, "Toward Better Net Assessment," *International Security* 13, no. 1 (Summer 1988): 50-89; Kugler and Domke, "Comparing the Strength of Nations"; and Bueno de Mesquita "Theories of International Conflict"; and John Alger, *The Quest for Victory*, appendices. In this way, the US Army Concepts Agency combed through historical battle data and found that when combined with surprise, innovative concepts made it likely for attacker to win. Michael E. O'Hanlon, *The Science of War*, (Princeton: Princeton University Press, 2009), p64. See also Richard K. Betts, *Surprise Attack*, (Washington, DC: Brookings, 1982), p5-16.

> "is one that derives maximum combat power from the resources physically and political available[427] [specifically,…] human and natural resources, money, technical powers, industrial base, governmental structure, sociological characteristics, political capital, the intellectual qualities of military leaders, and morale."[428]

Yet our concern here is not with these factors *per se*, but instead how well a stock of any given resources are transformed into losses inflicted on the enemy. As such, the best way to track proficiency is to quantitatively analyze what happens on the battlefield.[429] Measures of relative battle performance provide a clear answer to the question of who most ably deploys their forces amidst the various socio-political, technological, and organizational conditions of the time. To this end, the most basic method is to compare relative combat performance over time. At the very least, the approach offers means to consider whether Mahan was correct when he asserted that, "Historically, good men with poor ships are better than poor men with good ships."[430]

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[427] Allan R. Millett and Williamson Murray (eds), *Military Effectiveness*, 3 Vols, (Boston: Allen & Unwin, 1988), p2.

[428] Keep in mind that resource availability is not static. Particularly during war, raw material is rarely transformed into military product without cost or at a steadying rate. Factor mobilization and utilization instead face a series of natural and political constraints. Examples of the former variety include "geography, natural resources, the economic system, population, time, and weather." Similarly important are political considerations, such as the nature of "national political and diplomatic objectives, popular attitudes toward the military, the conditions of engagement, and civilian morale." Millett *et al*, in "Effectiveness," p2.

[429] Sample works include S.L.A. Marshall, *Men Against Fire*, (Washington, DC: 1947); Martin Van Creveld, *Fighting Power: German and U.S. Army Performance, 1939-1945*, (Westport, Conn: 1982); Trevor N. Dupuy, *Numbers, Predictions and War*, (Indianapolis, IN, 1979); E.S. Quade and W. I. Boucher (eds), *Systems Analysis and Policy Planning*, (New York, 1968); James F. Dunnigan, *How to Make War*, (New York, 1982); Robert E. Harkavy and Stephanie G. Newman, *The Lessons of Recent Wars in the Third World*, (Lexington, MA, 1985); George Quester, *Offense and Defense in the International System*, (New York, 1977); Lt. Col. Barry D. Watts, *The Foundations of U.S. Air Doctrine: The Problem of Friction in War*, (Maxwell AFB, AL, 1984). For an overview, see Millett *et al*, in "Effectiveness," p2. In absence of actual war, civilian and military leaders rely on war-gaming scenarios to help predict how the multiple factors that underlie proficiency will come together in a real conflict.

[430] Alfred Thayer Mahan, in Gray, *Another Bloody Century*, p100, fn #3

4.2 Research Design

Methodological Scope

Considering proficiency only in aggregate (that is, in terms of overall performance) is a relatively modest endeavour. It requires conceding that proficiency does not appear *a priori*, but instead is ultimately the product of a multitude of factors outside the scope of this study. An aggregate proficiency score is merely an intervening variable in the causal chain between the ultimate roots of proficiency and victory on the battlefield. Still, such a concession does not diminish the value of this study. This work is, in fact, a vital precondition to further research, for the emphasis ascribed to proficiency will count for naught if it cannot be shown that proficiency has consistently resulted in victory over time. There is little value to studying proficiency if its effect on battlefield outcomes is ambiguous. The most pressing question any leader—military or civilian—can ask is whether or not their army is going to win. There would be little reason to study proficiency if the conclusions drawn from our research could not help provide an answer.[431]

Some critics remain unconvinced of the utility of proficiency theory, arguing that such questions are no more than the pursuit of the banal: "no prizes are awarded for the less than brilliant insight that better armies tend to beat worse armies."[432] Yet such comments display far greater confidence in the relationship between talent and triumph than the literature warrants. To the author's knowledge, there is no broad-reaching empirical evidence to substantiate this claim, leaving only intuition and anecdotal evidence. These are both highly dubious foundations upon

[431] As O'Hanlon observes, even uncertainty in our science can be a good thing. It can demonstrate to policymakers just how risky a proposition war is, and thus how cautious they must be when considering it. In any case, modeling war's outcomes will take place anyways, whether it be "mathematically and systematically, or anecdotally and impressionistically." When a state considers war, it is certain to calculate its odds of winning. O'Hanlon, *Science*, p65-6.
[432] Gray, *Another Bloody Century*, p113.

which to base decisions so grave as those of war and peace. Moreover, the historical record may prove counter-intuitive. A quick consideration of the German case confirms such potential, for although Germany's superior performance in both World Wars is taken is most quarters as an article of faith,[433] a long line of catastrophic defeats paved the way to the *Reich's* destruction. In that case, better armies not only were beaten why those of an inferior quality, but they were soundly thrashed in as brutal and as devastating manner possible. So perhaps Gray is wrong to consider the relationship as straightforward. As we have seen with the poor showing of the 'bigger battalions' hypothesis,[434] folk wisdom can pale terribly when confronted with evidence.

Another, more potent, criticism is the worry that proficiency arguments fall prey to circular reasoning. As Sabin notes, "there is a degree of circularity in assigning qualitative categories based on historical performance."[435] Using past fighting experience to determine *current* fighting capability offers a prospective tautology. Loss ratios are, after all, *post hoc* measures tabulated upon a battle's conclusion. In other words, we have to wait until the struggle is won before acquiring a sense of which belligerent 'performed' better than its opponent. What if, then, superior loss ratios are simply a reflection of victory, rather than a demonstration of consistently superior combat ability? What if superior loss ratios and victory are essentially the same phenomenon? In other words, how are we able to judge the relative effectiveness of military forces *prior* to battle, for only that will provide a prediction of which belligerent will win before the actual contest takes place.[436]

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[433] Authors such as Stephen Ambrose would dissent, but they are very much viewed as in the minority. See, for example, Ambrose, *D-Day: June 6, 1944: The Climactic Battle of World War II*, (Simon & Shuster, 1995), whose subtitle gives the game away.
[434] See chapter 2.
[435] Sabin, *Lost Battles*, p21, speaking of Biddle, *Military Power*.
[436] An ability to accurately predict the outcomes of war is crucial, given that if belligerents could know with certainly the likelihood of their defeat, they may not engage in violence in the first place. In other words, would we have fought World War I if the world knew Germany was more proficient than much-lauded France? As Arquilla notes, "In land wars, where 'skill' reigns supreme, it is impossible ever to know with certainty which side will 'fight

This argument misunderstands proficiency theory's chief causal claim. While historical performance (that is, the relative balance of casualties preceding victory) is indeed the main measure of combat effectiveness, the concern here is not proficiency in and of its own accord. Instead, what matters is how well battlefield performance translates into command of the terrain. Victory and combat performance are not the same thing. Indeed, rather than the outcome being a simple reflection of the premise, the independent and dependent variables under study here are actually quite discrete. One can measure combat performance even in the absence of considerations regarding victory. In fact, battlefield outcomes are far from the only dependent variable that proficiency can affect; morale, public perceptions, and leader popularity all stand as further factors. More tangibly, even blundering armies win and the best soldiers can be routed. The Red Army, for example, was frequently outperformed by the German *Wehrmacht* in World War II. Yet this imbalance in casualties did not prevent them from standing firm at Moscow (1941), retaking Stalingrad (1942), and conquering Berlin (1945). Such results suggest that outcomes are not inextricably tied to the theory's premise.

Operationalizing Proficiency: Concepts, Hypotheses, and Validity

How best, then, to systematically compare combat proficiency between armies, and then contrast it to battle outcomes? How to separate the sterling armies from the second-rate? The approach adopted here uses casualty 'exchange ratios' as a way to infer which side acquitted themselves more effectively on the battlefield. This method is not without precedent.[437] Its chief

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better.'" Arquilla, *Dubious Battles*, p134. Given how difficult this task is, no wonder initiators get their predictions wrong so often.

[437] Implied in the introduction to J.F.C. Fuller, *The Conduct of War, 1789-1961*, (New Brunswick, NJ: Rutgers University Press, 1961), and elaborated by Frank L. Klingberg, "Predicting the Termination of War: Battle Casualties and Population Losses," *Journal of Conflict Resolution*, vol. 10 (1966), p129-171, the latter of which was heavily concerned with civilian "suffering" as well. See also United States Army Concepts Analysis Agency, "Do Battles and Wars Have a Common Relationship Between Casualties and Victory," (Technical Paper CAA-TP-87, 1987); Dupuy, *German Genius for War*; Dupuy, *Numbers, Predictions, and War*, Dupuy *Understanding War*,

virtue is the fact that relative casualty rates are the ultimate expression of combat proficiency. Being able to maneuver and attrite the enemy at a favourable exchange rate—and do so without capitulation—is at the heart of what military effectiveness is all about. This is so even when an attritional strategy has been adopted. In the Great War, for example, British generals accepted that attacking forces would sustain greater losses than defenders, protected as they were by trenches, barbed wire, and blockhouses. They were so willing partly because they knew the Entente had a larger manpower pool from which they could draw, meaning the Germans would run out of men first. But more importantly, the generals accepted these initial losses because they assumed that once the German line was pierced a breakout could be achieved. This would in turn open the prospect of encirclement and wholesale destruction of the Kaiser's armies, thereby returning the balance of casualties to the Entente's favour and bringing the war to an end. That the British failed miserably in this objective is evidenced by the grim casualties borne by the country's 'Tommy Atkinsons' and 'Addington Pals'. As Haig must have pondered on his long, daily horse rides behind the front, if an army is inflicting fewer casualties on an opponent than it is suffering in return, things are not going well.

Having adopted this approach, there are two separate measurements that can be used. The first is battle *score*.[438] This is the balance of total casualties—killed, wounded, and taken prisoner[439]—one belligerent inflicts upon another, relative to the casualties they themselves

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Arquilla, *Dubious Battles*, p79, 94 fn #22; and Biddle, *Military Power*. Formal modelers of war are even more eager exponents of this approach. See, for example, Jerome Bracken et al, *Warfare Modeling*, (Alexandria, VA: Military Operations Research Society, 1995); Wayne Hughes, *Military Modeling*, (Alexandria, VA: Military Operations Research Society, 1984); John Battilega and Judith Grange (eds), *The Military Applications of Modeling*, (Wright-Paterson AFB: Air Force Institute of Technology Press, 1984). See also the models reviewed in Stephen Biddle, "The European Conventional Balance," *Survival*, 30, 2 (March/April, 1988), p99-121; John Bode, *Indices of Effectiveness in Genera Purpose Force Analysis*, (Washington, DC: BDM, 1974), BDM-74-070-TR.

[438] A measure derived from Dupuy, *German Genius for War*, (1977), p328, 330.

[439] Some may question why prisoners are included in this metric, given that their distribution to decidedly favours the victor and that, on the main, they do not appear until an army has broken. The are because war is not just about killing and dying, but also using superior technique to demoralize the enemy. America's march into Iraq in 1991,

endure.[440] Battle score provides an indication of the relative balance of combat effectiveness because it gives a sense of which belligerent was able to inflict the most damage on the battlefield. A second measure, created by the author, offers an even more nuanced description of combat performance—though at the cost of a heavier data requirement.[441] The *Relative Loss Total*, or 'RLT,' is a measure of enemy casualties incurred per friendly soldier engaged. The effect is to 'normalize' numerical discrepancy, for it is a per unit measurement, not a function of the army as a whole. This makes it a more effective measure than the combat score because, by examining combat results *per solidus*, it controls for inequalities in initial force size. Larger armies that are halfway competent may have an easier time inflicting casualties on the enemy simply because of their tremendous bulk, thereby skewing performance assessment in favour of numerically superior forces. It therefore merits consideration of not just the relative exchange of casualties, but how well a force can 'punch above its weight' while so doing.[442] The RLT provides that service.

Relying on the ratio of casualty results to measure combat success is not without its drawbacks. Any time historical measures are used the concern is that the passage of time will

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for example, was so swift not because US forces managed to kill or wound the majority of Saddam's forces, but rather because the devastating might of America's advance so demoralized the Iraqis that they surrendered *en masse*. For historical evidence regarding how war is more war than just a matter of kill ratios—where things like deaths as a percentage of manpower lost, the morale of each sides' troops and civilians, and so on are more central to victory, see Ferguson, *Cash Nexus,* p96. Indeed, the surrender or flight of an enemy is more important than merely inflicting death and wounds—an act which is still generally a consequence of military skill. Foch, for example, cites approvingly the observation that "It is not so necessary to annihilate the enemy combatants as to annihilate their courage." (p287). He went on further, arguing that victory therefore requires to "break the enemy's will." (p286-7). "Victory is ours as soon as the enemy has been brought to believe that his cause is lost." "An enemy is not to be reduced to impotence by means of complete individual annihilation, but be destroying his hope in victory." Indeed, the "decisive victory, the true victory, is bound to be a moral victory." (p287). Marshall Ferdinand Foch, *The Principles of War*, Hilaire Belloc (trans), (New York: Henry Holt, 1920).

[440] Mathematically, this is written as Ascore: Bcas/Acas; and Bscore: Acas/Bcas, where each score is a reflection of the relative balance in casualties between A and B.

[441] Relative Loss Totals require peak strength in addition to the casualty totals require by the battle score method. This added empirical burden is particularly for battles set during the two World Wars, as firm deployment figures are often hard to come by.

[442] Mathematically, this can be written as Arlt: Bcas/Aengaged, Brlt: Acas/Bengaged. In other words, the Relative Loss Total of a belligerent is the product of the amount of casualties inflicted on the enemy, per force engaged.

obfuscate and eradicate the data necessary for quantitative analysis. It is inevitable that the data involved will not be perfectly reliable. Even so, corroboration by similar studies offers to place such worry in perspective. Indeed, a useful way to determine the reliability of historical data is to compare one set of findings to another. Comparison of the results of Dupuy's World War II relative combat performance study and data from the Correlates of War (COW) database, for example, show an impressive degree of concordance. Dupuy concluded that the Germans performed about two times as well the Allies, with casualty scores of approximately 1.25:1 versus the British and Americans, and 2.5:1 against the Soviet Union.[443] This number fits well with the COW's overall ratio of 2.03:1, in favour of the Germans.[444] The relative agreement between the two series of metrics—obtained through separate studies—is striking, and suggests the numbers offered by historians are not without a modicum of reliability. Moreover, when in doubt of the finds, one can always switch to more qualitative studies, to subject quantitative claims to further tests of verification.[445]

Related to the above, the chief worry regarding the validity of the inferences made here is the matter of causal sequence. This is the worry of endogenity, or the fear that the independent variable appears as a consequence, not as a cause of the dependent variable. In other words, what if proficiency—measured through loss exchange ratios—is not the source of victory, but rather a reflection of victory itself? Loss rates are snapshots taken at the *end* of a particular battle, done so in order to encapsulate how well an army performed *during* the battle itself. [446]

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[443] See Dupuy, *Understanding War*.
[444] Arquilla, *Dubious Battles*, p80. See also, Small and Singer, *Resort to Arms*, p91.
[445] In this case, the work of Millett and Murray agree that the Germans dramatically outfought their rivals in the Second World War. Millett and Murray, *Military Effectiveness*.
[446] Incorporating POW figures in relative loss totals is particularly worrisome, given that most are incurred after a battle has shifted decisively against the eventual loser. Losses of killed and wounded also tend to be inordinately inflicted when an army is in flight. Yet on balance it is best to include these figures given that the losses are imposed not from victory *per se*, but because of the military ability of the army who has broken the will of its opponent. Armies collapse because they are fighting armies that demonstrate superior maneuver, overwhelming

On the face of it, this is a worthwhile concern. Troops in flight are in a poor position to defend themselves and generally fare worse than their pursuers. It would therefore be fair to assume that defeat skews relative loss rates against the vanquished, at least to some degree.

The assumption, of course, is that differing rates of combat proficiency are what lead to an army breaking in the first place. Martial resolve does not disappear without reason, and it is fair to presume that broken armies display inferior combat effectiveness both before and after the point of their dissolution. Even so, this is by no means an ideal circumstance. Given that causal sequence cannot be proven, the conclusions that follow are thus more a reflection of the uncertainties of correlation than the certitude of causation. There is the potential that another lurking, unseen causal variable is affecting battle outcomes. All that we can do is appreciate the insights loss ratios offer in the analysis done here, and keep in mind that:

> "such single-index measures of complex phenomena are never fully satisfactory in reliability and validity, and that they usually undergo improvement as they are put into use and their inadequacies become evident. As the science of world politics develops, we trust that the measure at hand will not only prove useful to many researchers, but will experience whatever improvement and refinements turn out to be necessary."[447]

Hypothesis

The central hypothesis of this paper is that the side with greater combat ability, as represented by incurring rate of losses on the enemy, will emerge victorious. This is in accordance with Patton's maxim that "It is not your duty to die for your country, but to make the

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force, an obvious advantage, and so forth. These virtues *precede* victory. Armies do not collapse simply from an *a priori* condition of defeat. Thus while there will be bias towards the victor in the results, that is simply the nature of battle. To prevail is to be inordinately rewarded.

[447] J. David Singer and Melvin Small, "The Diplomatic Importance of States, 1816-1970: An Extension and Refinement of the Indicator," in *Correlates of War, II*, p222.

other poor dumb bastard die for his."[448] More formally, the relationship between proficiency (denoted here as 'E', for 'effectiveness') can be written as:

- H(E): when the proficiency figure of A is greater than B (as measured either by *score* or *relative loss total*), A will emerge victorious.

We move now to an evaluation of how well this hypothesis performs in light of the available evidence.

4.3 Data Analysis

Results

The dataset includes sufficient data to examine casualty scores in 395 cases. These range from Kadesh (1294 BC) to Lebanon (2006).[449] Analysis of the relationship between a superior ability to inflict casualties—the mark of superior proficiency—and victory uncovers a powerful conclusion. Of all the battles studied, a striking 82.5% resulted in victory for the more proficient side. Not only is this a much more impressive aggregate result than that obtained by the rival preponderance and military technology theories, proficiency's success appears to be extremely consistent through time.[450] The return of victory to a superior casualty balance goes no lower than 79% of battles engaged in the 1900s, the theory's worst-performing period. In other words,

[448] Cited in Knox and Murray, *Dynamics*, p55.
[449] Unfortunately, one of the biggest data gaps is found in the post-9/11 era. This is because estimates of enemy combatants lost to action are incredibly difficult to come by, given both the recentness of these battles (historians have had little time to examine competing reports), along with the nebulousness of the guerilla forces engaged.
[450] See chapters 2 and 3.

even when proficiency demonstrates its least powerful relationship to victory, superior military performance brought victory roughly 8 out of every 10 times.[451]

As we have seen, the chief drawback of casualty scores is that they assume both belligerents enter combat in a position of equality. This is in fact a rare occurrence, and thus we turn to the RLT metric. The downside, however, is that Relative Loss Totals require even more data, thereby shrinking the number of available cases to 320. The 20th century sub-set, for example, boasts less than half as many RLT cases as its do casualty scores. The problem of missing data is particularly apparent for battles of the Great War and its successor.[452] Nevertheless, the results are similar to the casualty scores above. In aggregate, 78.4% of armies who were—pound-for-pound—more adept at war than their counterparts, emerged from battle victorious. Although proficiency is by no means a guarantee of victory, this is a noteworthy result and a remarkably high figure.

[451] Arquilla's findings reached a similar conclusion. In his work, superior skill was associated with victory in 93% of his "land wars" (*n*=30), and 88% in "land-sea" wars (*n*=33). Arquilla, *Dubious Battles*, p83-84. Note, however, that Arquilla's enthusiasm for the importance of "skill" lies mainly in regards to "land" wars. For "land-sea" conflicts, which include a naval element, Arquilla finds the chief causal determinant to be maritime power, rather than skill or numbers.

[452] Knowledge of RLT ratios would be especially useful when considering the evolution of German tactics in the later part of World War I. Eventually, this can be done, but it will take additional work to translate unit deployment data into rough estimates of peak troop deployments for battles in both the First and Second World Wars, given that they are now assigned mainly for fronts.

Table 4.1 Proficiency & Victory Over Time (casualty scores vs RLT, by epoch).

Epoch	% Proficient Wins			
	Datapoints	Casualty Score (%)	Datapoints	RLT (%)
-1500	1	100.0	1	100.0
-500	15	93.3	15	93.3
500	22	86.4	23	91.3
1500	98	84.7	95	82.1
1800	139	82.0	134	76.1
1900	120	79.2	52	67.3
Aggregate	*395*	*82.5*	*320*	*78.4*

Another way to look at the relationship between proficiency and battle outcomes is to test for a correlation between them. While the RLT data traced above is ratio in nature and therefore well-suited to this purpose, the win/loss variable is categorical and therefore not. Unfortunately, the only ratio data available to stand in for the latter is 'relative battlefield performance.' This is measured by transforming battle casualty data into ratio form. The lower this number is, the fewer casualties a belligerent endured in relation to the enemy. The higher the number, the worse they fared on the battlefield. An obvious concern is that both the independent and dependent variables rely on casualty measures, opening up the danger of a prospective tautology. Both sides of the causal equation are being impacted, at least in part, by the same force. Just as important is that battlefield losses are not the dependent variable this study is after. Here we are most concerned with victory, as defined by geographical control. The comparison is not, however, without utility. An army can fight proportionately better that its opponent and yet still end up with a worse casualty situation. Imagine an army of 1,000 fighting an army of 10,000.

Suppose the smaller force fought extremely well, inflicted more casualties per soldier than its opponent did in return, but in the end it was overwhelmed and defeated with a loss of the entire force. So long as the total casualties endured by the larger army did not exceed 1,000, it would be possible for the smaller force to have a superior RTL score and yet face an unfavourable casualty balance. The logic is thus that if you perform better than your opponent, and yet still endure more casualties, things probably did not go so well on the battlefield. History is replete, after all, of tiny forces who fought valiantly and yet were overrun and killed to the last man.[453]

Table 4.2 Hypothetical High RLT and Unfavourable Casualty Balance (A outfights, but more casualties).

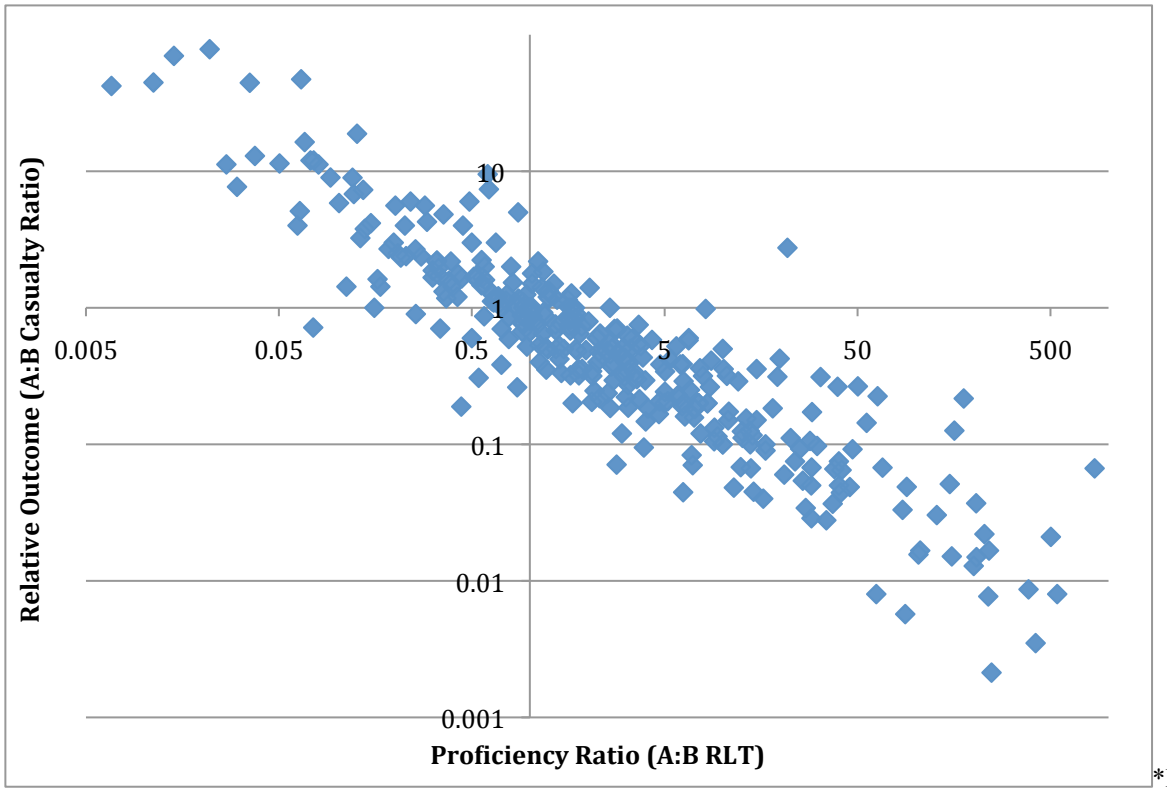
Example	Army Size	Casualties Endured	RLT	RTL Ratio (A:B)	Casualty Balance (A:B)
A	1,000	1,000	0.9	9	1.11
B	10,000	900	0.1		

This leaves us at a crossroads, where proceeding forward with inferential statistics requires recognition that the results of observations using both RLT and casualty scores are tenuous in the extreme. We therefore look to figure 4.3 with interest, but also a heavy grain of salt. This being said, contrasting relative combat performance with casualty outcomes provides us with the relationship that we anticipate. As the graph below indicates, armies that fought well on the battlefield—that is, incurred many losses on the enemy for each casualty they endured in return—emerged with a relatively favourable balance of casualties. Those that did not found themselves in the unenviable position of being high up on the top-left quadrant of the graph—the

[453] Think, for example, of Thermopylae 480 BC and Rorke's Drift 1879.

place where combat performance was lowest and the casualties endured were most intense. The *Pearson Coefficient* is -0.066, with a *Standard Error* of just 0.0029. There are exceptions to this, and the trend is not perfect. The R2 is no better than 0.004, after all. Yet the basic plot outline concurs with proficiency theory's assumption that superior combat performance coincide with better battlefield outcomes.

Figure 4.3 Performance and Relative Outcomes (A:B RLT vs A:B Casualty Ratio).

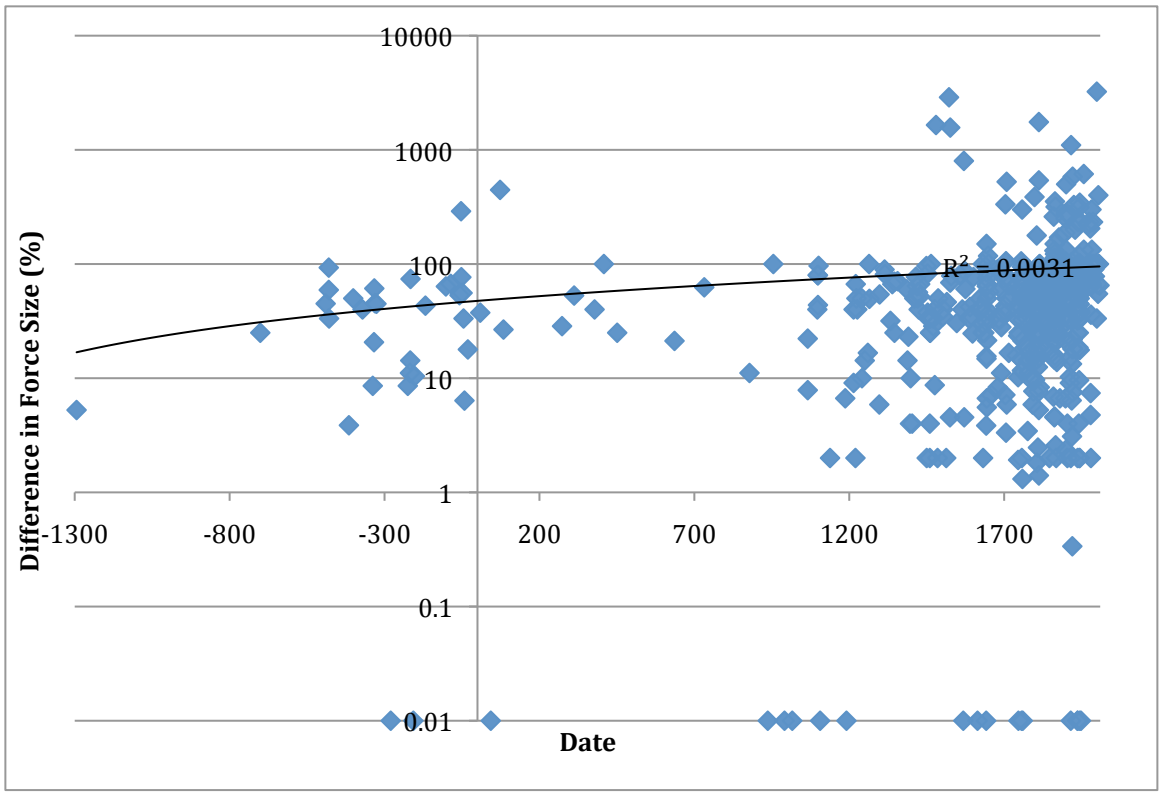


*Based on 320 battles, ranging from Kadesh (1294 BC) to Lebanon (2006). Pearson: -0.066. Standard Error: 0.003. *p-value*: 0.217.

Similarly interesting is an examination of differences in force size. There is sufficient data to measure just how much larger one belligerent is than another in 531 cases. Of this two observations are noteworthy. First is a slow but consistent trend towards greater disparity in

forces. The trend line in figure 4.1 demonstrates how the percentage difference between two forces has gone steadily upward over time. Compared to the titanic battles of the 20th century, for example, the struggles of antiquity were more evenly matched.[454] We will discuss the potential implications of this in the next section.

Figure 4.1 Difference in Force Size Over Time (absolute values; includes 0% difference).



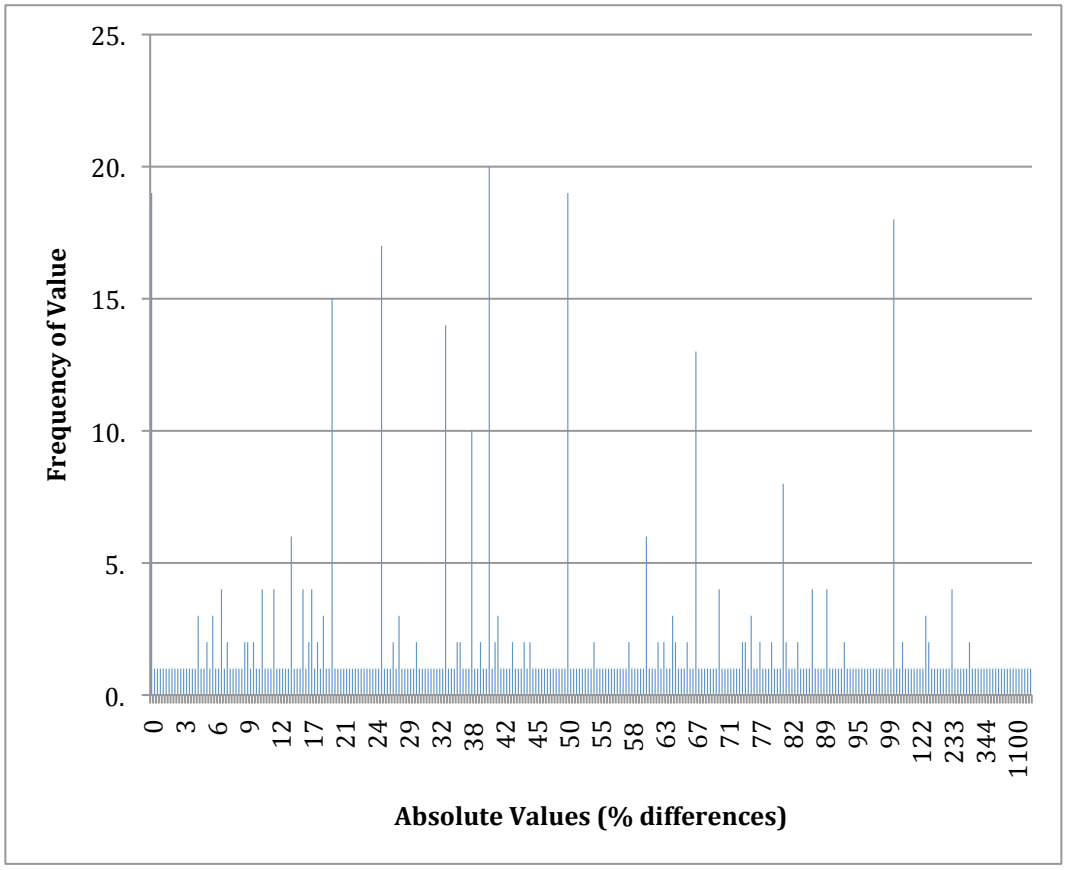
*Based on 531 battles, ranging from Kadesh (1294 BC) to Wanat (2008).

[454] This may be a reflection that the empirical record is biased in favour of battles fought between squabbling-but-literate empires and not the innumerous tribal societies that lived under civilization's shadow. It is plausible that this biases the data in favour of the relatively even matched competitors for Greek and Roman hegemony, and against the battles presumably fought by imperial forces against much-larger barbarian armies. However, neither does the evidence indicate this, nor did the development of advanced civilization stop nations in the 20th century from deploying armies of vastly disparate size.

The second observation is that when the historical distribution of difference values is broken down in a frequency table, it becomes clear just how rare it is for armies to meet each other on even terms. In only 39 of 531 available battles was the fighting conducted between forces less than 5% different in size. For example, if a belligerent in one of these 39 cases was 100,000 soldiers strong, their opponent would be 105,000 soldiers or less. For force differences of 10% and under (say, an army of 100,000 fighting armies of 110,000 or less), the number grows to a mere 68 battles. This is equal to just over one in ten cases in the total sample population. In contrast, an astounding 387 battles were fought when there was a 25% or more discrepancy between belligerents (armies of 100,000 troops fighting those of 125,000 or greater). This result is equal to almost three-quarters of available cases. In other words, the historical norm has been for two armies to meet in highly *unequal* terms, at least as a matter of raw numbers. The implication is that generals behave in the way the numbers suggest: that proficiency matters. Military leaders must be confident that their skill[455] can overcome numerical preponderance, lest they not meet on the battlefield in the first place. Even if an army's intelligence branch had failed miserably and failed to appreciate the proper size of the advancing army, flight is still an option the moment the asymmetry becomes apparent—when forming up ranks on the battlefield, for example. For an army to stay in the field in the face of superior numbers is to believe those numbers can be overcome. To pursue an engagement otherwise would be completely irrational.

[455] A technologist would suggest 'technology' here as well. Yet the confidence logic still applies, since is not good enough to have a miracle weapon. You also have to be confident you can put it to good use. Few of Hitler's generals were convinced that weapons like the Me-262 and V-series rockets were going to win the war, no matter how impressive these feats of engineering were.

Figure 4.2 Frequency of Force Size Differences (%, absolute values; 1294 BC to 2008).



*Based on 531 battles, ranging from Kadesh (1294 BC) to Wanat (2008).

Despite this powerful evidence, the confirmation of proficiency theory is not perfect. One disconcerting sign is that the results for both RLT and casualty score performance demonstrate a modest, albeit consistent, decline over time. As the centuries have advanced, so too has the likelihood that the more capable will be defeated. Indeed, as showed in Table 4.1, returns to RLT supremacy in the 20th century slipped to 67%, a far cry from the aggregate figure of 78%.

The reason for this drop-off in causal efficacy is likely twofold. First may be the matter of data insufficiency. Efforts to measure RLT in the 20th century are plagued by a lack of necessary data. The consequence is that the RLT results incorporate less than half the number of battles that the casualty scores do. True, many of the battles included in the casualty score results but not the RLT findings would likely confirm proficiency theory if the necessary evidence was available. Indeed, the absence of crucial battles that would otherwise indicate support for the theory is likely the reason why the decline in RLT performance is much more marked than those of the casualty scores. In World War II, for example, a presumably superior German army knocked off first the British and French at Arras (1940), followed by the British at Second Tobruk (1942). The same can be said of the Soviets at Khalkin-Gol (1939). Lacking the necessary data, however, we cannot substantiate this presumed congruence between theory and historical result. As a consequence, the results obtained here likely underplay the theory's predictive success.

More crucially, however, is that sometimes even the incredibly gifted are worn down by the bulk of their opponent. This has been repeatedly witnessed in industrial times, with the Second World War standing as a striking exemplar of the phenomenon. Even before the war in Europe ground down to a close, the German army faced a succession of catastrophic defeats even as it continued to outfight its rivals. The failed attempt to take Moscow (1941), Alamein I (1942), Kursk (1943), Salerno (1943), Cassino (1943), Aachen (1944), the Bulge (1944), and Berlin (1945) all maintain a consistent pattern: the Germans were more gifted at the art of war than their rivals, yet they did not prevail. As such, these battles pose the greatest challenge to proficiency theory, for in each case the hardened *Wehrmacht* outfought its opponents—a fact verified by the data—yet still faced a succession of crushing defeats. The German experience

therefore poses a serious quandary for proficiency theory: how is it that even the most supremely able war machines can, with some degree of frequency, lose? And why is this outcome becoming more frequent over time?

Why Do the Gifted Lose?

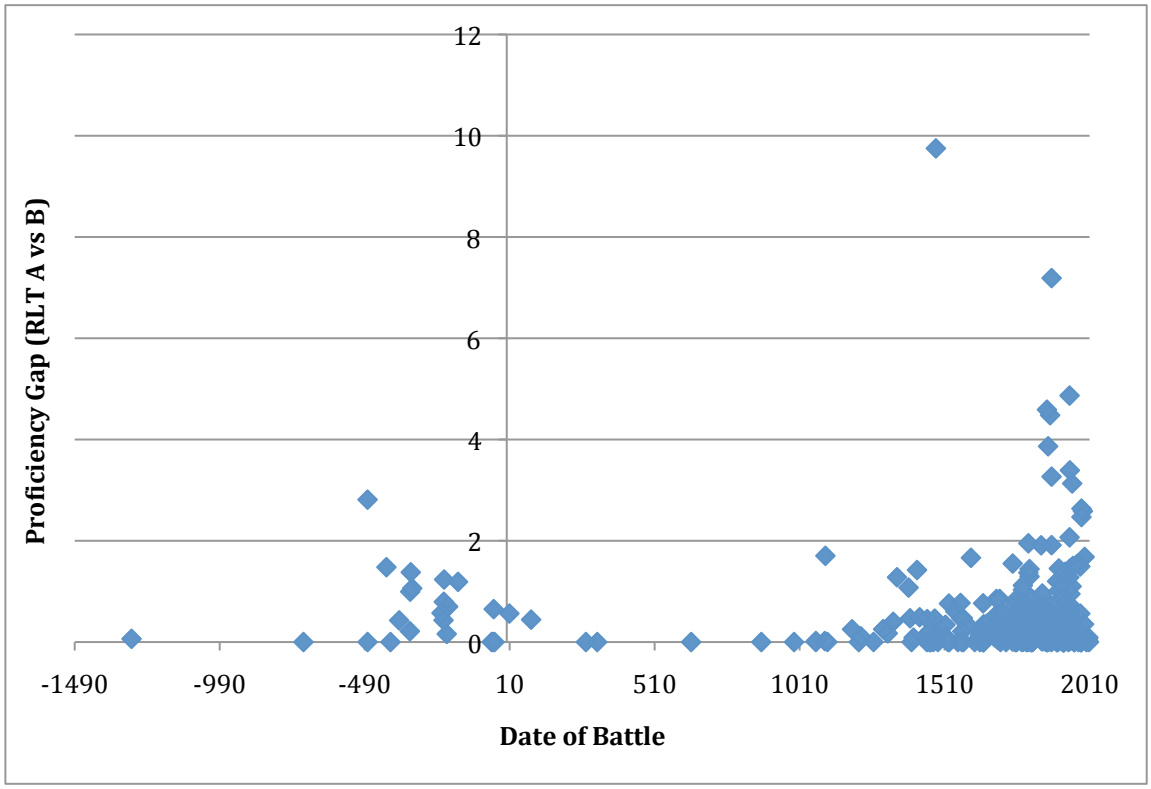
One plausible explanation is that the discrepancy in quality between armies has diminished in recent times. This is not an unreasonable assumption to make, given the tendency of pre-modern generals to achieve near-endless strings of victory against hopelessly inferior foes. The genius of Alexander and Genghis Khan, for example, were unparalleled in their time, as were the armies they led. Many of their enemies were terribly overmatched even before battle began. In contrast, even the most successful commanders of the last hundred years—think of Ludendorff, Manstein, and Yamashita—had no shortage of excellent contemporaries to challenge them. In economic terms, the supply of military competence has increased greatly in recent years. The widespread diffusion of Germany's *Kriegsakademie* model in particular has ensured that today countries as minor Albania and Uganda all boast institutions devoted to readying their officer corps for future conflicts—a preparedness that previous generations lacked.[456] It is therefore possible that the reduced returns to proficiency in recent years is simply a reflection of there no longer being such clear divide between the capable and the incompetent.

The problem with this interpretation is that examining the 'proficiency gap' between armies over time suggests that discrepancies in capability between contending armies are as great today as in the time of Caesar and the Gauls, if not wider. As figure 4.4 shows, there has often been a marked distinction in performance ability between belligerents right up to modern times. Blundering armies still get formed and trundle off to war. The assumption of force capability

[456] They even have established a presence on the web. See http://www.tradoc.mil.al/ and http://www.flickr.com/photos/usarmyafrica/3774510632/.

equalization is therefore not likely to be the reason why the proficient were so much more likely to go down in defeat in the 20th century and the 1st AD.

Figure 4.4 Proficiency Gap over Time (RLT discrepancy, chronologically ordered).



*Based on 320 battles, ranging from Kadesh (1294 BC) to Lebanon (2006).

Instead, a more plausible explanation is that despite preponderance theory's apparent causal insignificance,[457] it is possible that under certain circumstances numerical supremacy can play an increasingly determinative role. As the Second World War repeatedly showed, it is possible to outwork and outmaneuver an enemy—and yet still suffer defeat in the face of superior numbers. Exhaustion can cripple even the most talented army. The Finns, for example, dramatically outfought the Russians in 1940-41, and yet were forced to sue for peace by relents

[457] Depending on the metric, the preponderant have won in history only about 50% of the time. See chapter 2.

Soviet numbers. The Greek defeat at Thermopylae (480 BC) operated in the same manner. No matter how well the powerful Greek infantry fought—backstopped by a contingent of Spartans, arguably the finest soldiers of the age—the vast Persian army had sufficient reserves to wear down all the courage, strength, and geographic favour the Greeks could muster. Even the talented French army, helmed by one of the great captains of history, lost Paris (1814) after a massive allied invasion force bore down on it. The lesson is that even the gifted can survive preponderance only for so long.

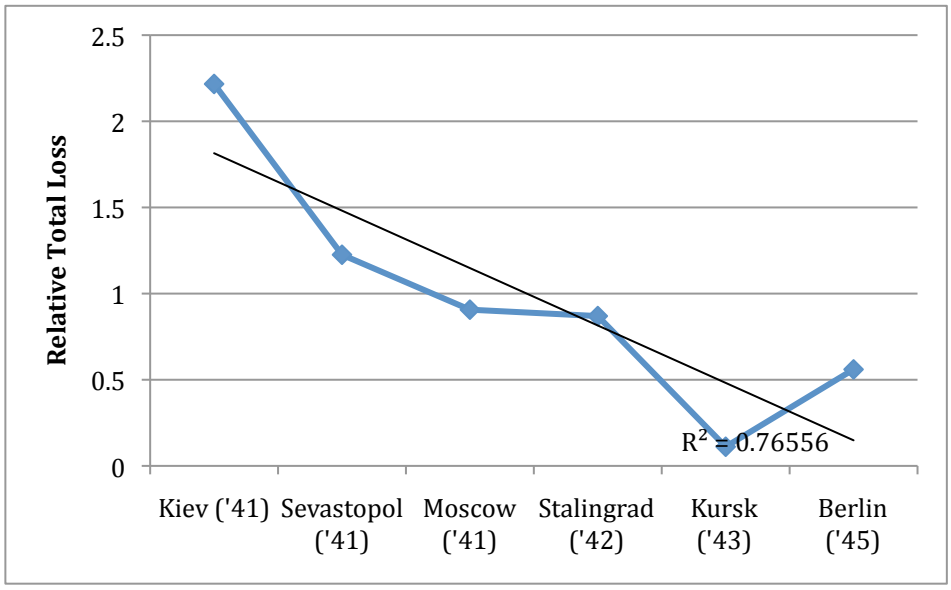
A useful way to describe this dynamic is 'proficiency erosion.' Given how large the German World War II case bulks in the study of military proficiency, it is worth considering the German army's performance over time. There, as the enemies piled up and Germany's manpower pool steadily eroded, the capability of Germany's war machine—one that appeared so invincible from Poland in September 1939, all the way all the way to Moscow in December 1941—steadily worsened. In fact, when all the available data is plotted, Germany's average RTL results plummeted by more than half between 1940 and 1945.[458] When the results are separated by front, to control for the opponent, the results are even more stunning. Germany slipped from a 2.5 score at Kiev (1941)—a number almost 15 times that of the Red Army figure—to just 0.5 during the final battle in Berlin (1945), where the Germans barely outfought the Soviets. As the long years of the titanic Russo-German struggle wore on, the great material reserves of the Soviet Union, working alongside its fast-improving army,[459] combined to grind

[458] See statistical appendix.

[459] The improved performance of the Red Army was noticed as early as just a few months into the war. Guderian, on a trip to front before approaching winter of 1941, observed a T-34 for the first time. "Our defensive weapons available at that period were only successful against the T-34 when the conditions were unusually favourable. The short-barreled 75mm gun of the Panzer IV was only effective if the T-34 was attacked from the rear; even then a hit had to be scored on the grating above the engine to knock it out. It required very great skill to maneuver into a position from which such a shot was possible. The Russians attacked us frontally with infantry, while they sent in their tanks in mass formations against our flanks. They were learning." (cf K p199)

the vaunted *Wehrmacht* literally to dust.[460] "A handful of Panzer divisions, however brilliant their tactical and operational handling, did not prove capable of meeting the mobilized power of entire continents."[461] The increasingly desperate efforts of the Germany's superlative armed forces were not enough to stave off rapidly diminishing combat power, and ultimately defeat.

Figure 4.5 German Proficiency, Eastern Front (RTL, by battle—chronologically ordered).



It is possible that proficiency's role has diminished in recent centuries because the grinding attrition that favours preponderance theory has had more opportunity to take effect. Premodern struggles were often characterized by a few pitched battles, followed by swift capitulation or parades through conquered territory. Persia's two offensives against Greece typify such behaviour. Following his bloody defeat at Marathon (490 BC), Darius I simply turned around and went home. When his son, Xerxes, returned in 480 BC, a series of titanic struggles took

[460] That German performance rebounded slightly during Berlin (1945) is likely the result of the tremendous defensive preparations made in the defence of that city (see Anthony Beevor, *Fall of Berlin 1945*, Penguin, 2003), alongside the fact that the Soviet army itself was facing severe attritional pressure. See Catherine Merridale, *Ivan's War: Life and Death in the Red Army, 1939-1945*, (New York: Picador, 2006).
[461] Martin van Creveld, *Technology and War*, p164.

place, culminating with Salamis (480 BC) and Plataea (479 BC).[462] Once again, a few key, discrete battles determined the campaign's outcome in relatively short order. In contrast, as modernity approached, so too changed the nature of battles. Technology, the industrial revolution, and advances in transportation and social organization ensured that no longer were battles decisive, single-day engagements of old. Instead, they now had a tendency to transpire over days, if not weeks, and—by the First World War—for literally months on end. No longer was talent provided relatively singular opportunities to shine, but instead subjected to what O'Connell has described as a "perpetual motion machine," one where the great bounty of this economic revolution "was shipped to fronts dedicated to its consumption using the same assembly-line principles by which it was created."[463] The effect was to turn armies "into little more than killing machines."

If the Great War demonstrated the horrific potential of industrial slaughter, the Second World War demonstrated its perfection. The Eastern front in World War II in particular can be seen in this manner.

> "At times the death struggle between the forces massed by the German Wehrmacht and Red Army never seemed to stop. From the Battle of Kursk in July 1943 to the Crimea in early May 1944 military operations involving hundreds of thousands of soldiers continued day in and day out. Then, after a pause lasting barely a month and a half, Soviet forces attacked the German Army at the end of June 1944, and the ferocious fighting in the east continued without letup until the collapse of Hitler's regime."[464]

[462] Thermopylae (480 BC), and certainly ranks high in the popular imagination, but in terms of total Greeks deployed, it pales in comparison to the truly massive Plataea, where a good 80,000 Greeks were deployed.
[463] Robert O'Connell, *Of Men and Arms*, (Oxford: Oxford University Press, 1990), p254.
[464] Murray & Millett, *Military Effectiveness*, pvii.

In short, the Russians and Germans fought almost without interruption. This allowed ample opportunity for proficiency erosion to do its work. World War Two was the pinnacle of this trajectory away from wars of decisive annihilation and towards long, drawn-out wars of attrition. It is therefore unsurprisingly to see here proficiency erosion at its most pronounced.

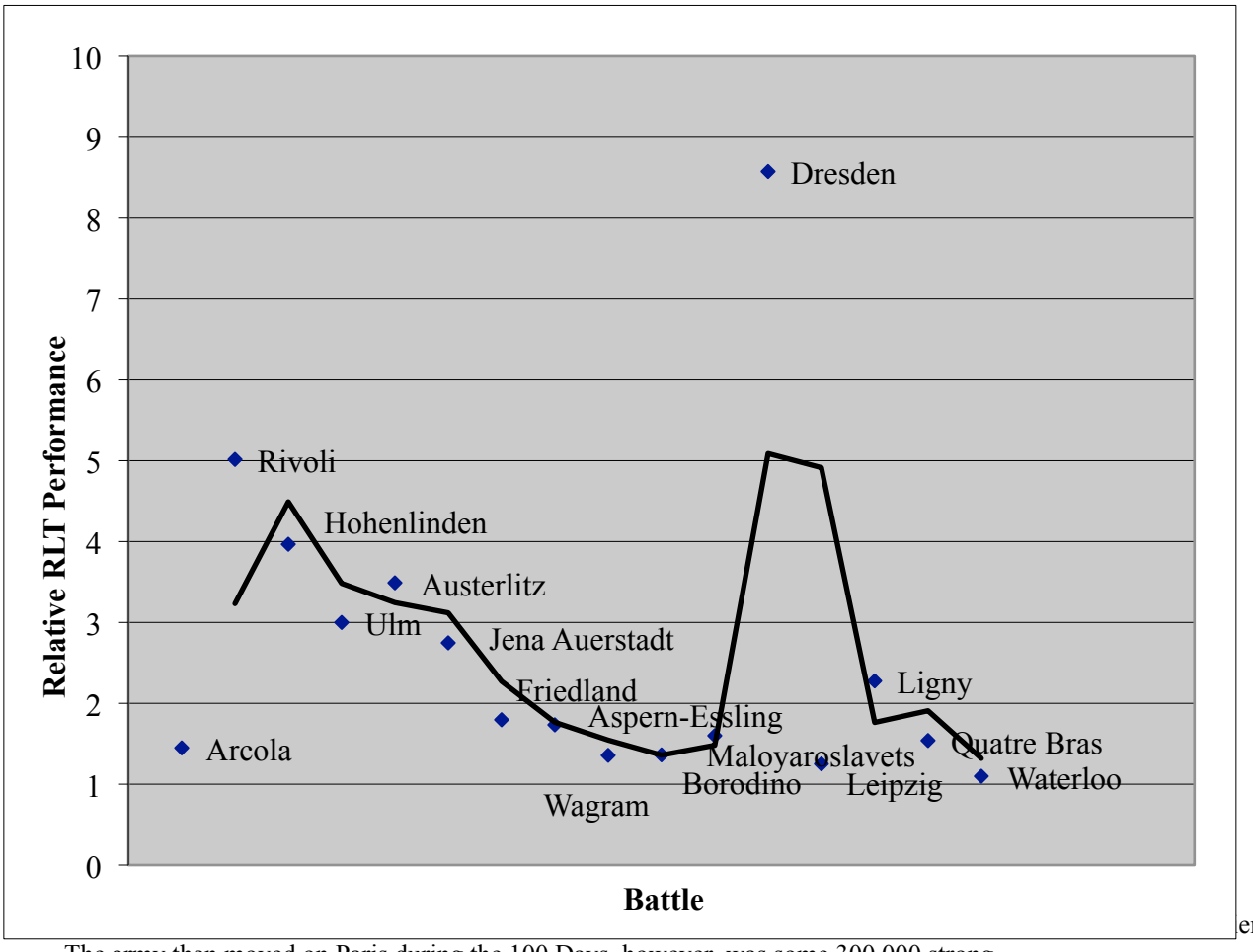
This does not mean that the dynamic of proficiency erosion is limited to modern times. Indeed, close examination of loss exchange ratios demonstrates erosion at work in drawn-out struggles throughout history. Take the favourable RLT ratios enjoyed by Hannibal, Napoleon, and Lee at the pinnacle of their success. In each case, army performance faced incredible downward pressure as the number of battles mounted. The Confederates, for example, averaged a combat effectiveness 1.7 times greater than their Union opponents, yet by the end of the war struggled to achieve parity in individual engagements. In fact, as the war's final battles were concluded, such as at Five Forks (1865) and Appomattox (1865), the exhausted South could manage no more than 38% of the North's performance. That the tables so decisively turned is perhaps unsurprising, given how relentlessly the South was being worn down by the far numerically-superior Northern armies. Grant's instructions for Sherman's 'march to the sea' were to turn the Shenandoah into "a barren waste…so that crows flying over it for the balance of this season will have to carry their provender with them."[465] The bedraggled remains of Lee's army stood as a testament to these efforts.

Napoleon faced a similar trajectory. It is widely observed that the quality of Napoleon's army greatly diminished as his endless series of wars progressed. The conscript masses at Borodino (1812) and Leipzig (1813) were by no means as efficient as the fresh, young corps at Lodi (1796), Marengo (1800), and Austerlitz (1805).[466] The evidence bears out this trend.

[465] Cited in Parker, *Warfare*, p237.
[466] Knox and Murray, *Dynamics*, p94.

While Ulm (1805) and Austerlitz demonstrated French effectiveness almost 3.5 times greater than the Russians and Austrians, by the time of Wagram (1809) this figure had fallen to 1.5. Similar figures were witnessed at Borodino (1812), Leipzig (1813), and Quatre Bras (1814), all of which were far below Napoleon's average performance of 2.6 times his opponent's. By the time of Waterloo (1815), French performance had fallen to little better than equal its enemies'. "The alliance of 1813 at last mobilized the continent's resources sufficiently to overwhelm Napoleon's tactical-operational genius."[467] The once invincible *Grand Armee* had slowly become all too mortal.

Figure 4.6 Proficiency vs Preponderance Over Time (RLT moving average, battles of Napoleon).

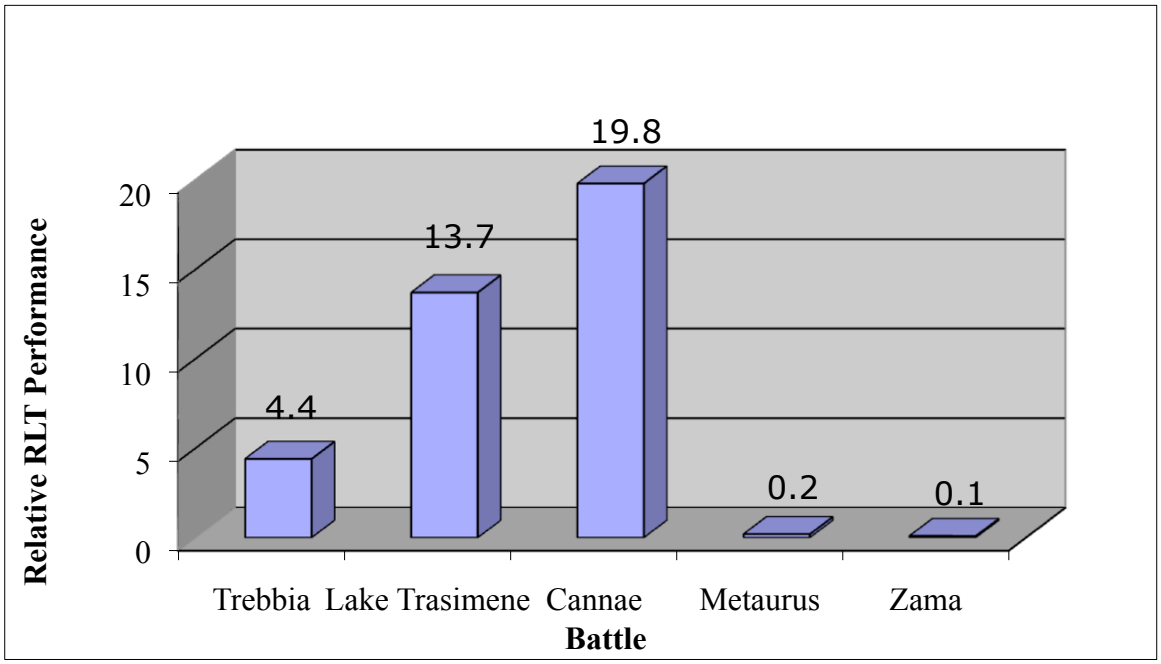


ers. The army than moved on Paris during the 100 Days, however, was some 300,000 strong.

Worse, though, was the fate that befell Hannibal's forces. Set against a Roman Republic willing to continue the struggle for decades on end, the once-mighty Carthaginian army was, by the time of Zama (202 BC), comprised mostly of untrained levies. It faced this predicament because Hannibal's remarkable initial triumphs could not stem the losses inflicted by Quintus Fabius' strategy of refusing open battle with the Carthaginians. The Romans instead eluded the frustrated Hannibal and forced his army to "exhaust their supplies and men in futile chases."[468] The fifteen years between Cannae (217 BC) and Zama (202 BC) were deeply unkind to Hannibal's army, particularly given that it failed to foment an anti-Roman rebellion and secure new recruits amongst Roman subjects in the Italian peninsula. Nor did Hannibal's recall to North Africa offer much respite. There were available sons to replenish the Carthaginians depleted colours. All told, Carthaginian battle performance plummeted from an average superiority of 7.7 times the Roman's in the early stages of the Second Punic War, to a mere 10% of Scipio's forces at the concluding battle of Zama (202 BC). Cato the Elder demanded "Carthage must be destroyed." Despite boasting one of history's greatest captains in its ranks, the city was. Over time, even terribly imbalanced victories can turn to losses—a condition of which no amount of genius can reverse.

[468] George Kohn (ed), *Dictionary of Wars*, (New York: Checkmark Books, 2007), p427. See also Nigel Bagnall, *The Punic Wars: 263-146 BC*, (Osprey, 2002).

Figure 4.7 Proficiency vs Preponderance Over Time (RLT in comparison, battles of Hannibal).



Proficiency erosion is generally felt after a series of engagements. As time progresses, the military performance of even the most gifted troops can degrade when facing a steady supply of fresh enemy troops. But it can also be at play within a specific engagement itself, so long as the discrepancy in numbers is sufficiently large and the battles last long enough for attrition to perform its deadly work. Imperial battles in particular often demonstrate this phenomenon, where even tremendously capable forces have become surrounded, overwhelmed, and destroyed. Perhaps the most famous example is Isandlwana (1879), where spear-armed warriors utterly

defeated British professionals, hardened in endless imperial campaigning.[469] Similar examples range from Caesar's experience in Britain, to the Norsemen in North America, to Freeman's unit in 1866 in the US Indian Wars. Others include Meyer's Drift during the Zulu War, the French fighting the Tuareg of the Sahara in the 1890s, and the Germans in Southwest Africa.[470] Innumerable close calls dot the historical record as well, including several in the modern era. On November 20, 1925, for example, 3,000 Druze rebels surrounded 120 French Legion cavalry at Fort Rachaya in Syria. The company was saved from a relentless attack only by the arrival of a relief force four days later. Even then, just 35 Legionaries were left alive. Once again, the historical lesson is that while proficiency matters most, it is not everything.

An Alternative Needed: What of a Combination of Proficiency and Preponderance?

All of this points to the need to attach a caveat to proficiency theory. While favourable loss-exchange ratios are a demonstrably crucial precursor to victory—again, those demonstrating superior proficiency have historically won their engagements about 80% of the time—the proficiency that matters so much to victory can evaporate in the face of superior resources. Against a tenacious, overwhelmingly preponderant adversary, even the most gifted militaries can be driven to exhaustion.[471] Unfortunately, none of the literature's existing theories adequately capture this dynamic. Perhaps a combination of the proficiency and preponderance explanations can rectify this shortcoming.

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[469] Adrian Greaves, *Isandlwana*, (Cassell & Co, 2001); and Ian Knight, *Isandlwana 1879: The Great Zulu Victory*, (Osprey, 2002).

[470] For a brief survey of primitive cultures prevailing over civilized ones, see Lawrence H. Keeley, *War Before Civilization: The Myth of the Peaceful Savage*, (New York: Oxford University Pres, 1996), p71-81.

[471] An alternate explanation is that it takes time for a belligerent to 'warm up,' rather than the battle dynamics being a matter of grinding down. Martin Middlebrook, for example, writes of the British Army "leveling up" and the German Army "leveling down" in the years prior to the Kaiserschlachten. Yet if one looks at the raw performance of these forces, the leveling down is by far more important. For example, the difference between the old BEF and Kitchener's Armies is striking. So too can this be said of the elite German Jäger divisions, as the war wore on. There is, then, 'learning by doing', but this cannot match the attrition of prolonged struggle. A series of battles is therefore more about endurance than learning.

The question, then, is: how do the two fit together? For this a few cautious answers can be offered. On one hand, enjoying both superior numbers and more expert skill is a virtually unbeatable combination. Such conditions emerged in 90 separate battles within the dataset. In all but 7% of available cases (84 of 90), the combination of preponderance and greater proficiency resulted in victory. Again, while neither virtue ensures victory on its own—for the preponderant can be poorly trained or terribly mishandled (such as the Soviets in early 1941), while the more proficient can be simply overwhelmed (such as the French at Leipzig in 1813)—the combination of the two is virtually unbeatable. Defeat in such circumstances requires either great misfortune or a supreme miscalculation of the strategic situation. The surprise British assault at the Plains of Abraham (1759), for example, left the French totally disorganized and unprepared to ward off the attack. Despite the French colonial army demonstrated tactical superiority at Fort William Henry (1757) and Ticonderoga (1758), Montcalm and his forces could not recover in time to hold the city.[472] For the Russians at Liaoyang (1904), defeat was a matter of insufficient confidence in their position. Although the Tsar's forces had inflicted greater casualties on the Japanese, General Kuropatkin, believing himself beaten, "began a systematic, well-managed withdrawal north toward Mukden."[473] It is therefore possible to enjoy both superior numbers and a favorable loss ratio, yet still face calamitous operational or tactical developments—or even a loss of nerve. Nevertheless, the overwhelming historical tendency is that when better armies hit the field in greater numbers than their opponent, victory is almost certain.

Table 4.2 Both Preponderance & Superior Proficiency (numerical strength & RLT figures).

[472] General Montcalm himself was killed in the melee that ensued, as was the British commander, James Wolfe. See D. Peter Macleod, *Northern Armageddon: The Battle of the Plains of Abraham*, (Douglas & Mcintyre, 2008).
[473] R. Ernest and Trevor N. Dupuy, *The Encyclopedia of Military History*, (New York: Harper & Row, 1977), p924.

Total Battles	Proficiency & Preponderance = Victory	%
90	84	93%

Next is the matter of when a belligerent enjoys *either* preponderance or proficiency, but not both. The reason we do this is to remove the instances where a belligerent is doubly privileged. This leaves an isolated comparison of the two competing independent variables: preponderance and proficiency. The dataset offers 249 instances of this type, for which proficiency and preponderance data are available. Analysis of the results is interesting, for among these cases, superior proficiency (measured in Relative Loss Totals) won 75% of the time. Critically, this number is almost precisely in line with the RTL measure's aggregate historical average. When disaggregated by epoch, the data also demonstrate congruence with earlier findings, particularly in regard to the steady erosion of proficiency's ability to secure victory. Whereas proficiency outfought troop preponderance 12 cases to 1 in antiquity and 14 to 1 in the medieval epoch, the 19th century saw the proficient-but-outnumbered prevail in only 71% of cases, and just 60% in the 20th century. This decline lends credence to the argument that the industrial and manpower potential unleashed by modernity has provided greater opportunity for attrition to play a role in battle outcomes. In effect, preponderance is now better able to make up for a deficiency in fighting capability than in preindustrial times.

Table 4.3 Either Preponderant or Superior Proficiency (numerical strength & RLT figures).

Epoch	Total Cases	Superior Proficiency =	%	Average Preponderance

		Victory		Preponderance = Victory	for Inferior Victors
-1500	13	12	92.3	1	14.3
500	15	14	93.3	1	1.4
1500	62	53	85.5	9	2.4
1800	106	75	70.1	31	5.9
1900	53	32	60.4	21	3.2
Aggregate	*249*	*185*	*74.7*	*63*	*2.69*[474]

The results indicate that proficiency can be eroded in any epoch. There comes a point when any army, no matter how gifted at the art of killing, can no longer bear the weight of numbers against it. The likelihood that it will, however, increases dramatically when an era's political, economic, and social conditions permit the mobilization of resources on an industrial scale. Ages characterized by the *levee en masse* and incessant war production are less about singular contests—where skill can prevail prior to exhaustion setting in—than drawn-out campaigns, where proficiency is ground down by the unceasing nature of industrial war. Alexander's march across Eurasia, for example, is noteworthy not because the great captain's megalomania ensured his empire remained perpetually at war, but rather that his conquests were achieved by discrete engagements, divided often by months if not years. As titanic and bloody as battles like Granicus (334 BC) and Gaugamela (331 BC) were, there reigned relative tranquility between these contests. The nature of pre-industrial battles was to be terrible, but singular and relatively isolated affairs. This afforded the Greek pikemen and cavalry time to rest and recuperate in preparation for the next battle. Similarly beneficial for the Greeks is that the

[474] With outliers removed. See below.

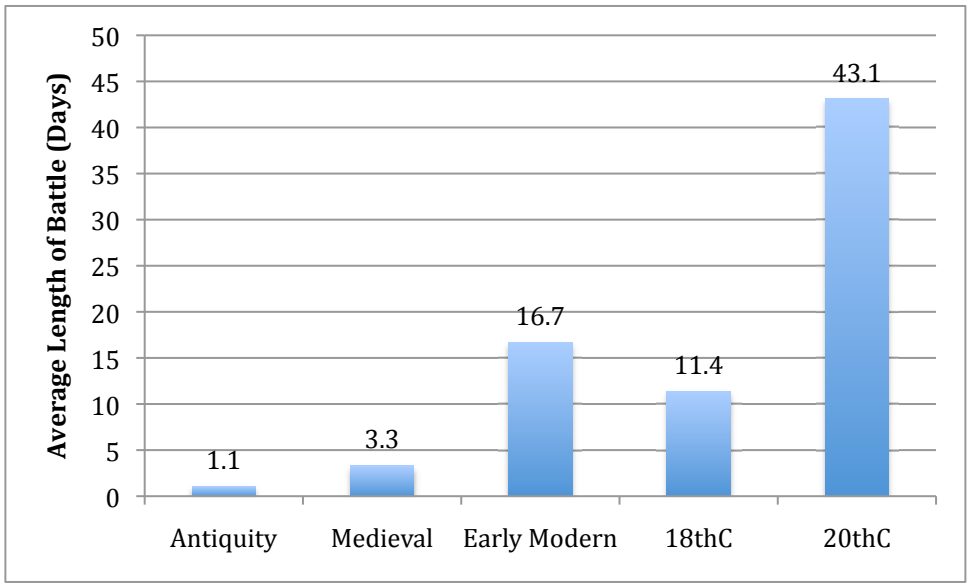
passage of months or even a year between battles would do little to change the material balance between armies. Lightly-armed infantry are called to the colours quickly. But once these soldiers are mobilized there remain few additional military resources to draw upon. Time therefore allows the wounded to heal and the exhausted to rest, yet adds fresh troops only as fast as conscript classes reach maturity and fresh allies are secured. In this way, pause can be seen to favour the proficient and disadvantage the preponderant.

In contrast, the material resources made available in the industrial era offer no such favours to the exceptionally talented. Rather than war of individual engagements, where skill is allowed to flourish, triumph here is usually only slowly and painfully achieved. This is evidenced by the dramatic increase in battle length over time. Outside the early modern era—a period characterized by a historically inordinate number of long sieges—the trend is a remarkably steady increase in the number of days a battle took to complete. Whereas an individual encounter could be expected to last about a day in antiquity, by the 1800s an average battle lasted almost two weeks; in the 1900s, more than a month. More to the point, such prolonged struggle favours the preponderant significantly. This is because the longer a battle lasts, the more opportunities there are for the materially preponderant to bring their capital resources (such as tanks and guns) to bear on an opponent, all while the proficient have little chance to recover from the steady drain on their resources. The closing years of World War II, for example, saw German divisions perpetually shuttled from one front to another, observing barely any pause in the fighting. As Lieutenant Rolf-Helmut Schröder, a twenty-four-year-old adjutant of the 18th Volksgrenadiers, noted "The last time we attacked in Russia, we formed up on the start line straight off the train."[475] Given their cumulative losses and the relentless pressure placed on them by the Allies, it is unsurprising that despite a steady—albeit

[475] Cited in Max Hastings, *Armageddon: The Battle for Germany, 1944-1945*, (New York: Vintage, 2004), p81-2.

diminishing—superiority in tactical ability, Germany could not hold out. In other words, in the industrial era it becomes much easier for the unskilled-but-materially-preponderant to catch up to the proficient. Proficiency erosion is therefore a powerful explanation as to why the gifted sometimes lose.

Figure 4.8 Engagement Length (per battle, in days).



*Note: The Siege of Rhodes is removed from Antiquity, given its role as the only battle of its kind in that sub-sample.

It does take, however, on average a massive level of preponderance to offset combat inferiority. After removing the most extreme instances of disproportionally in troop deployment figures (that is, removing the four instances where one army was ten or more times larger than its opponent from the calculation), we are left with 59 instances where the militarily less-capable belligerent prevailed. What is important here is just how great a discrepancy in numbers was necessary to overcome the disadvantage in relative skill. Of these cases, an average numerical preponderance of 2.7 was needed to secure victory.[476] Put another way, when a belligerent was less capable than his adversary, it would take an army roughly three times the size to carry the day. In this way, armies like Montgomery's at First Alamein (1942) could defeat wily Rommel

[476] The battles removed are Thermopylae (480 BC), Camerone (1863), Isandhlwana (1879), and Fort Sumter (1862). With these battles included, the average belligerent discrepancy for preponderant-but-outfought victors is 4.6 times their opponent. The median, including all battles, is 1.93.

and his vaunted and his highly proficient Afrika Korps by putting vastly greater forces into the field. Likewise it took the Allies 300,000 troops to defeat Kesselring's 100,000 at Cassino (1944). Given such crushing power, even the once supremely confident German officer class recognized after Kursk (1943)[477] that victory under present conditions was simply impossible.[478] They knew their army's unmatched skill would not save them.

4.4 Conclusions

Proficiency Matters

Many lessons lurk amidst the haunting legacy of World War I. One of the most crucial is how tactical and strategic adeptness are more central drivers to the determination of victory and defeat than technology or numbers. The great attrition battles of 1916 in particular demonstrate how unsurpassed concentrations of men and materiel did the belligerents no good. By the time of the Somme (1916), Britain had built a brand new, continental-sized field army some 70 divisions strong—a ten-fold expansion since peacetime. In this terrible battle 17 of these would be hurled into German lines along a 25-mile front, accompanied by shelling from 1,000 field

[477] "General Foy says in his memoirs that Napoleon's soldiers marched to Waterloo 'without fear and without hope,' and this sentiment aptly expresses the feelings of most German offices during the first months of 1944. The rank and file were more optimistic, for tactically the German Army was still superior to any of our adversaries, and the confidence of the men in their officers and weapons remained unshaken. There was talk of wonderful new inventions which would annihilate our enemies; moreover, Hitler's prestige was still a very potent factor. His spectacular rise to power, and the extraordinary triumphs between 1933 and 1941, inspired a hope that somehow or other this fantastic man would contrive to extricate Germany from her agony. But when one considered the overwhelming air power of the Anglo-Americans, the unlimited resources upon which they could draw, and the vast and unbroken might of the Soviet Union, serious students of war realized that the struggle could have only one conclusion." von Mellenthin, *Panzer Battles*, p277.

[478] As the war wound down Hitler himself placed his hope in tide-turning super weapons or other such miracles. Upon hearing of the death of President Roosevelt, he assumed compared it to "The miracle of the House of Brandenburg," where the death of the Czarina Elizabeth in 1762 and the accession of the pro-Prussian Czar Peter III, which had saved Frederick the Great in the Seven Years War. This was not to be, as Vice-President Truman assumed the Presidency and pursued the destruction of Germany with a determination no different than that of his predecessor. See John Keegan, *The Second World War*, (Penguin, 2005).

guns, 180 heavy guns, and 245 heavy howitzers. This massive concentration of men and guns would be used to bludgeon a hole in the German lines, through which reinforcements—cavalry in particular—would pour. This rupturing of the German's position would make it untenable, opening up the prospect of a deep penetration into their Belgian railheads and beyond. General Haig's orders were thus that the "assaulting troops must push forward at a steady pace in successive lines, each line adding fresh impetus to the preceding line."[479] Ultimately, Haig's view was that great enough numbers would see victory through.

To the south, the Germans had already begun putting the same principle to similar practice. At Verdun (1916), Falkenhayn aimed to force the French "to feed reinforcements into a battle of attrition where the material circumstances so favoured the Germans that defeat was inevitable."[480] To this end, he stocked the German positions with 2.5 million shells, and sat down to let the numbers do their work.[481] Tragically for both the British and Germans, numbers brought nothing but misery and desperation. The Kaiser proclaimed on April 1 that Verdun would bring an end to the war. Instead, Germany would end up with half a million casualties and invitation for further fighting. Over the course of the struggle some 40 million artillery shells were fired at Verdun by the French and German armies—about two hundred rounds for every soldier killed.[482] Lord Lansdowne typified the disbelief at the slaughter that resulted. Speaking of the horrifying British failure at the Somme, "We are surely but surely killing off the best of the male population of these islands…To many of us it seem as if the prospect of a 'knock-out' was, to say the least of it, remote…Can we afford to go on paying the same sort of

[479] Cited from Keegan, *The First World War*, (Toronto: Key Porter Books, 1998), p291.
[480] Keegan, *First World War*, p279.
[481] So intense was the shelling that when the battle began on February 21, Bois des Caures, 500 by 1,000 yards square, an estimated 80,000 shells fell before the German infantry appeared.
[482] Jay Winter and Blaine Baggett, *The Great War and the Shaping of the 20th Century*, (New York: Penguin, 1996), p166.

price for the same sort of gains?"[483]

Technology brought no salvation either. Often overlooked is the fact that the Germans did not find tanks in the Great War particularly frightening. At the Somme, where tanks were deployed for the first time *en masse*, mechanical problems and artillery brought all 36 to a halt little past their start lines.[484] The belching, iron monsters were not going to bring the war to a close by their own, and the Germans knew it. Instead, it was only when tanks were used in proper combination with other branches that decisive results were achieved. For example, German officers concluded that British tanks and infantry working alone would crack the German lines only 25% of the time. When deployed in combination with artillery, however, breakthrough was virtually certain.[485] A similar story is told by German successes in 1917 and early 1918. Rather than the product of technology, alone or in combination—the Germans had, for example, few tanks even at the war's conclusion—the *Reichsheer*'s stream of great victories in the war's penultimate stage, both West and East, occurred as a result of a series of tactical innovations that allowed the deadlock of trench warfare to be broken.[486] Germany's "genius for war"[487] enabled it to hold out for nearly five long years against a numerically and in many ways technologically superior enemy.

Proficiency matters at the tactical and operational levels, but so too does it at the strategic and political as well. The Second World War is replete with egregious examples. Most notable is how the talented *Wehrmacht* was harmed greatly by the ineptitude and ignorance of its high command, at least regarding questions of grand strategy. Failure, for example, to make peace

[483] Cited in M.J. Cohen and John Major, *History in Quotations*, (London: Cassell, 2004), p715.
[484] Keegan, *The First World War*, ~p298.
[485] Murray and Knox, *Dynamics*, p146.
[486] Known as the Bruchmüller system, the operational aim that the Germans developed was no longer concerned with flanking maneuvers and envelopment, but rather utilizing indirect firepower to secure dramatic breakthroughs at weak points to paralyze an opponent in depth. Murray and Knox, *Dynamics*, p151.
[487] Trevor N. Dupuy, *A Genius for War: The German Army and General Staff, 1807-1945*, (Prentice Hall, 1977).

with Britain after the failed Battle of Britain (1940) was likely unwise; a blithesome invasion of the Soviet Union surely foolhardy; and the unnecessary declaration of war on the United States bordering on lunacy. At each stage, Germany's political and military leaders made poor decisions, choices that would hamstring subsequent battlefield performance terribly. When invading Russia the army assumed the country would collapse "like a house of cards."[488] When war with America was considered, the German high command generally assumed that US industry was suited only to the manufacturing of radios and refrigerators.[489]

> "As to strategic assessment, there was none. The Kriegsmarine thought that a declaration of war was a good idea; the army and Luftwaffe could not have cared less. As his staff celebrated the news of Pearl Harbour, Hitler casually asked where Pearl Harbour was. No one knew."[490]

Locked in mortal combat along the frozen approaches outside Moscow, the frontline soldiers of the German army—rightfully proud of their unequaled tactical and operational proficiency—had more pressing concerns than the damnable strategic and political incompetence of their leaders. But they would suffer from this ineptitude all the same.

What we can see with the German World War II case is that while proficiency is the chief determinant of a military's potency, it can be eroded over time. Among the defenders of Hitler's bunker in the spring of 1945 were old men and untrained boys. Their performance could not hope to equal the battle-hardened 20-year olds who had fought their way across Europe just a few short years earlier. But they were all that was left of Germany's utterly depleted manhood.

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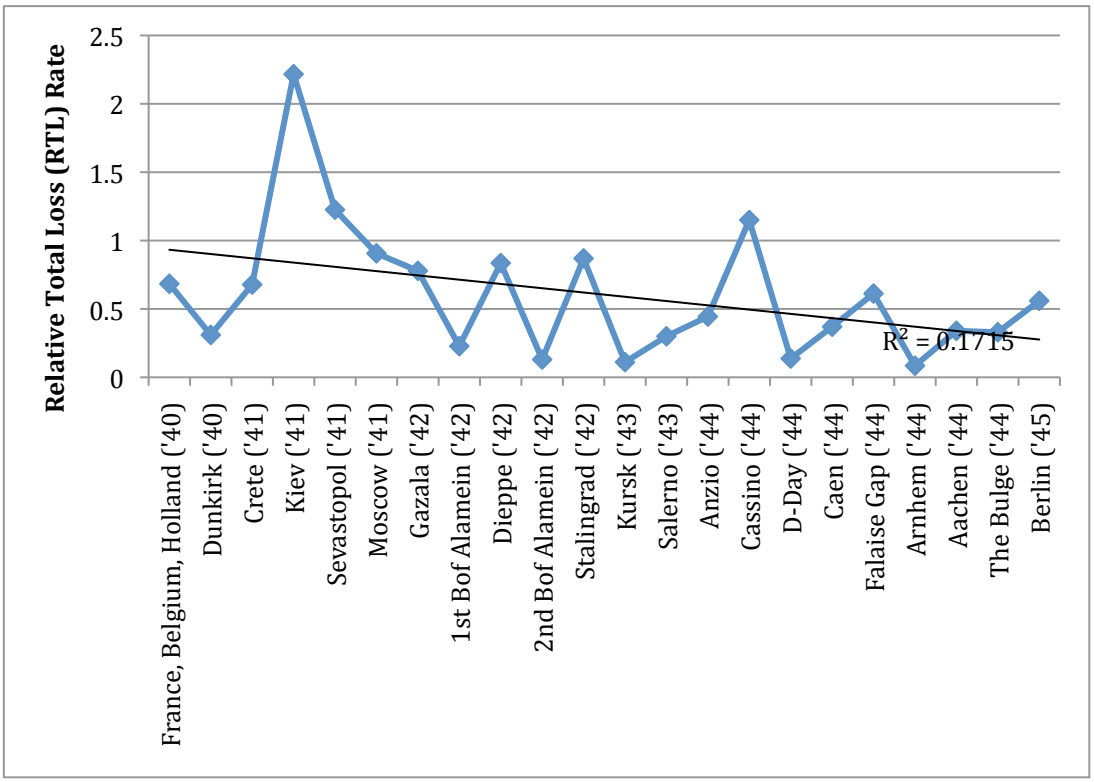
[488] See Millett and Murray, *Military Effectiveness*, p10 fn#19

[489] Nor were the generals alone in their misperception of the United States. Hitler derided the country as a "mongrelization of races," and failed to appreciate the contribution of 2 million US troops to the Entente's victory in World War I, concluding instead that defeat was the consequence of betrayal by the Jews and communists at home." Millett and Murray, *Military Effectiveness*, p135-6.

[490] Millett and Murray, *Military Effectiveness*, p136.

Proficiency, after all, is not a static force. It takes time to train new conscripts, and even the most seemingly unlimited pools manpower are in fact finite in their supply. When provisioned with numbers great enough, the preponderant can wear down the gifted as the river does stone.

Figure 4.4 Germany's WWII Performance (RLT).



The proficient are therefore not invincible. This leads to the study's perhaps the most urgent implication. While proficiency is a solid predictor of victory on the battlefield—again, proficiency and victory are found in accordance roughly 80% of the time—commanders of even the most gifted militaries must take heed of enemy numbers in the field. As has been demonstrated above, even the most advanced armies can be defeated by rudimentarily-armed opponents. Thus the thinly held NATO positions in Afghanistan's south must remain wary of being overrun by covertly concentrated Taliban forces. In fact, this has already nearly occurred.

July 2008 saw nearly 200 Taliban insurgents attack a remote American-run outpost along the Pakistan border. There the Taliban outnumbered the 45 Americans and 25 Afghan National Army soldiers by a ratio of almost 3:1. In rather startling congruence with the historical data, the Taliban came tantalizingly close to success, managing to breach certain portions of the compound's defences.[491] Only with desperate calls for air support were the attackers held at bay, and only just. So tenuous was the American's position that soon after the battle the position was abandoned.[492] The West should therefore never take their proficiency for granted. To do so would be most dangerous.

[491] Carlotta Gall and Eric Schmitt, "Taliban Breached NATO Base in Deadly Clash," *New York Times*, July 15, 2008. Nine Americans were killed, the worst single loss for the American military in Afghanistan since June 2005.
[492] BBC News, "US troops abandon Afghan outpost," July 16, 2008. www.bbcnews.com.

Chapter 5: Summary and Conclusion

Dissertation in Review

Some Concluding Thoughts on the Theories of Battlefield Victory

"Every one may begin a war at his pleasure, but cannot so finish it."[493] **Machiavelli**.

"You determine to go forward, though you don't know the way. Shuddering seizes you, the hair of your head stands on end, your soul lies in your hand. Your path is full of boulders and shingle, there is no passable track, for it is all overgrown with thorns, neh-plants and wolf's-pad. The ravine is on one side of you, the mountain rises on the other. On you go and guide your chariot beside you, and fear that the horse will fall….The sky is open, and you imagine that the enemy is behind you."[494] *Letter from **Hori**, an Egyptian scribe and veteran, to a young officer*.

Abstract

This chapter is a summary of the results obtained in this study, followed by suggestions for future research, along with a few policy suggestions. The central conclusion is that while the proficiency hypothesis fares best of the three main theories of battle victory, it is an imperfect

[493] Niccoló Machiavelli, "Money Is Not the Sinews of War, Although it is Generally So Considered," *Discourses on the First Ten Books of Titus Livius*, Christian E. Detmold (trans), (Modern Library, 1950), cited in Richard K. Betts, *Conflict After the Cold War*, (New York: Pearson Longman, 2008), p268.
[494] Leonard Cottrell, *The War Pharaohs*, (London: Evans Brothers, 1968), p99.

explanation. There does, after all, appear to be a role for preponderance explanations, at least in extreme circumstances. It is therefore urgently worth considering what lies at the root of preponderance, particularly in regard to the mobilization of resources over time.

5.1 Summary of Study Results

The Three Theories in Review

The first theory considered in this study was that of preponderance, a collection of hypotheses that hold in common the assertion that the belligerent deploying superior material resources will emerge victorious on the battlefield. The first of these, *H(P)1 ('troop preponderance')*, is concerned with battlefield deployment figures. Given preponderance theory's assumption that battles are won and lost by means of grinding attrition, it is an unsurprising contention that bigger armies will win in the battles they fight. However, in only 287 of 617 available cases—spanning from Megiddo (1469 BC) to contemporary operations in Iraq and Afghanistan—did this relationship hold, a confirmation of just 46.5%. Disaggregating the results by historical era offers similarly unfavourable results. Out of a total of eight separate epochs, preponderance theory manages to accurately predict more than 50% of battle results just once. Only in the 20th century, where 57% of preponderant armies emerged victorious, did preponderance offer a belligerent better than even odds of winning. In contrast, the results downplaying the role of preponderance were quite consistent. With the exception of the 1900s, from 1300 to the present saw the returns to preponderance remain mired in the mid-to-low 40% range. This ambiguity of the connection between preponderance and victory is further illustrated by scatterplotting the victor-vanquished ratio (chapter 2, fig 2.1). Overall, despite a gently upward-sloping improvement over time, the historical norm is thus for the belligerent enjoying

troop preponderance to in fact *lose* the engagement, a result precisely the opposite of what the troop preponderance theory predicts.

Other preponderance theorists suggest that it is not troop deployment numbers that are the causal variable of note, but instead aggregate economic wealth. They hold that successful warmaking relies on an army's capital intensity, rather than simply the numbers of troops under arms. In effect, material preponderance provides the firepower necessary to speed up the rate at which casualties are imposed on an enemy, ensuring that the victor of this grinding struggle is the side with greater economic resources. There are two ways to measure this wealth, with *H(P)2a ('economic preponderance': population)* relying on population figures as proxy for total wealth. Such data exists for 633 battles, of which only 336 saw the wealthier belligerent (again, as determined by population totals) emerge victorious. This computes to a bare majority of just 53.1% of all cases, which is hardly a ringing endorsement of the theory.

There are, however, shortcomings to operationalizing aggregate wealth in this way. Population works as an unbiased proxy for national wealth only until around the onset of the industrial revolution. Until this time, population could be counted on as a rough reflection of aggregate economic potential. But from the industrial revolution onwards we can no longer be as confident with population as a proxy for material wealth because we are no longer dealing with like units—at least when comparing regions of varied economic development. To control for this data validity problem, a shift to GDP estimates was made. This second method can be denoted as *H(P)2b ('economic preponderance': GDP)*. Although by no means perfect, these estimates provide a relatively precise view of the relative material balance between two belligerents. More specifically, of the 409 battles where such data was available, 254 cases confirmed the preponderance hypothesis. This computes to 62.1% of the engagement total, and

serves as a noticeable improvement over the casual success rates of the previous hypotheses. This result does not, however, stray far from the earlier concerns of causal ambiguity. No general can afford to sleep soundly when relying on odds little better than 60%.

Table 5.1 Preponderance Results (% of battles where preponderant won, by hypothesis & metric).

Hypothesis	Causal Metric	Total Cases	Causal Success
H(P)1	Troop preponderance.	617	46.5%
H(P)2a	Economic preponderance (population)	633	53.1%
H(P)2b	Economic preponderance (GDP).	409	62.1%

Second in popularity to the preponderance theory of victory is that which deals with technology's effect on military capability. Here is the argument that prevailing technological circumstances—known as the 'technological balance'—is the primary driver of victory and defeat. Technology's effects, however, can be felt in two ways: in either a 'systemic' or 'dyadic' fashion. In the former version, technology is seen as serving to either make it "easier" to conquer territory or to defend it, an effect felt system-wide. All nations will face this force in equal measure. The promise of technology is therefore to favour those who are aggressive when offence reigns supreme, and to privilege defenders when conditions are opposite. For example, the development of offence-favouring tanks will provide an attacking advantage to any state who builds them. In contrast, the dyadic proposition holds that technology matters only in a relative sense, or in terms of the distribution of technology between two belligerents. The side with superior technology to its opponent is assumed to possess greater power, regardless if they are

undertaking offensive or defensive operations. Dyadic theorists see the technological balance's "chief effect as favoring individual states over others, depending on their particular holdings."[495]

Each of these views offers a slightly different hypothesis. According to *H(T)d ('dyadic technology')*, when the technology of one belligerent is superior to another, the better-endowed will win. Of course, measuring the distribution of technology is fraught with difficulty, for technology does not easily lend itself to metricization. This study adopted GDP per capita as a rough approximation of the relative technological condition, and did so because the historical tendency is that as wealth *per person* grows, so too does a given society's level of technology. Overall, in 475 battles the technologically superior enjoyed victory a not-altogether unreasonable 63% of the time. This finding, however, is somewhat skewed by the large number of battles which were fought in the 20thC, a century where victory was visited upon the technologically superior belligerent an impressive 73% of the time. For the other periods, however, only the 1800s exceeded a 60% achievement of victory, while the rest hovered near 50% or worse. It cannot even be said that technology has become uniquely causally important in recent centuries, for while the post-2000 sample is extremely small (and thus statistically unreliable), its findings suggest that the potency of technology may have declined once again.

Table 5.2 Dyadic Explanatory Efficacy (by interval, 0-1499 for first interval, by century thereafter).

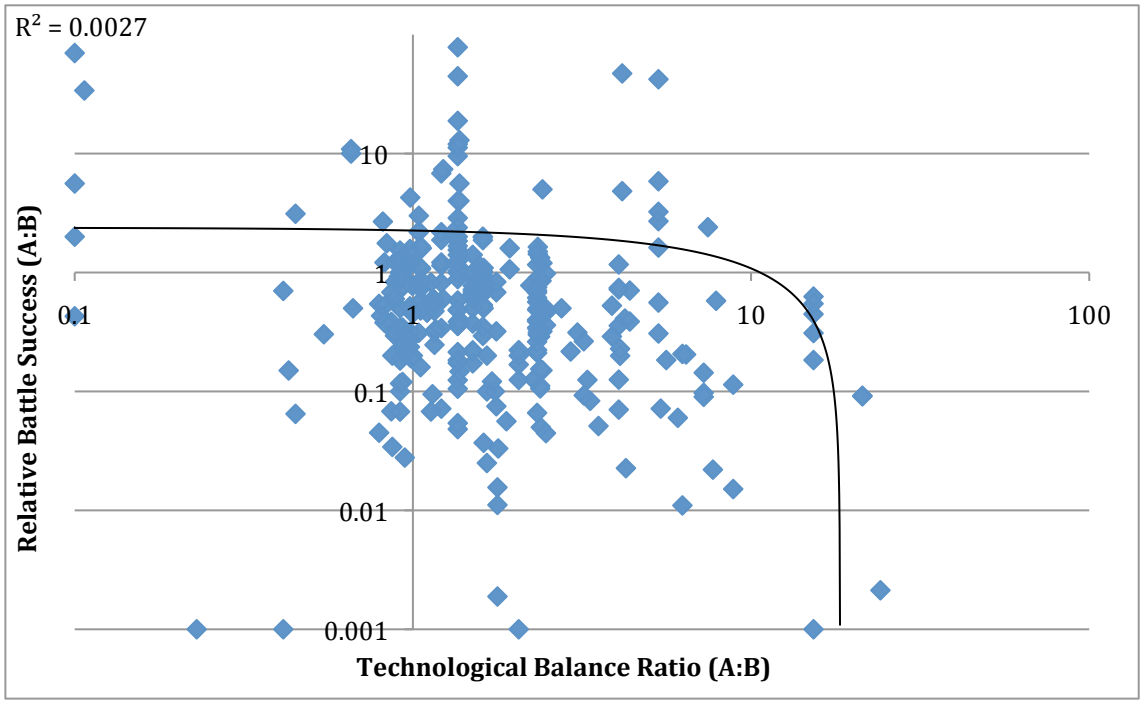
	Total Battles	# of > GDP per cap Victories	% of > GDP per cap Victories
0s	7	4	57.1%
1500s	12	4	33.3%
1600s	16	8	50.0%

[495] Stephen Biddle, *Military Power*, (Princeton: Princeton University Press, 2004), p16.

1700s	71	37	52.1%
1800s	153	96	63.1%
1900s	211	151	71.6%
2000s	5	3	60.0%
Overall	*475*	*303*	*63.9%*

A scatterplot of the relationship between relative technological supremacy (using per capita GDP as proxy) and battle outcomes furthers the damage to technology theory. The expectation of the graph is that the line of best fit should be a clear diagonal, from the top left quadrant to the bottom right. In other words, as technology gap between belligerents goes up, the casualties endured by the superior side should go down. The results, however, do not meet this prediction. Only in cases of extreme technological imbalance, shown at the far lower right of the graph, is the tendency to achieve a low level of relative casualties achieved. For the rest of the cases, the causal effect of technology appears to be slight. Rather than a decisive trend indicating that superior technology is rewarded with lower casualties, the plots appear randomly scattered—a lack of causal direction reflected in the mostly static nature of the trend line. Improving one's relative technological position does not consistently result in improved battlefield performance. Indeed, the empirical data simply does not behave in the way the theory suggests, deeply undercutting the persuasiveness of the dyadic hypothesis. The deployment of superior technology simply does not ensure success on the battlefield.

Figure 5.1 Dyadic Technology Theory Performance (technology balance vs relative battle success, A:B).



The best way to test for *H(T)2 ('systemic technology')* is to discover whether or not there exist clear historical patterns of victory by either attackers or defenders. This test is a reflection of the assumption made by systemic theory that technological conditions favour one strategic orientation or the other. If technological conditions are biased towards offence, attackers should enjoy an inordinate number of victories. However, when examining the 565 cases between the years 1300 and 2000—according to periods divided into centuries—rather than the series of distinct oscillations between offensive and defensive success, there is often little difference in the return to a particular force posture. Not until the 1500s is there a clear favouring of defensive action, with offence leading to victory in just 36% of the battles conducted. Thereafter, the profitability of offence returns to its rather muddled state, with attacker success hovering around the historical average of about 60%. All of this suggests that technological conditions do not

shift decisively, as technology theory predicts. The impact of technological developments can therefore only be modest at best.

Table 5.3 Systemic Technology: 1300-2006 (100-yr intervals; %'s converted to whole numbers, w/decimal).

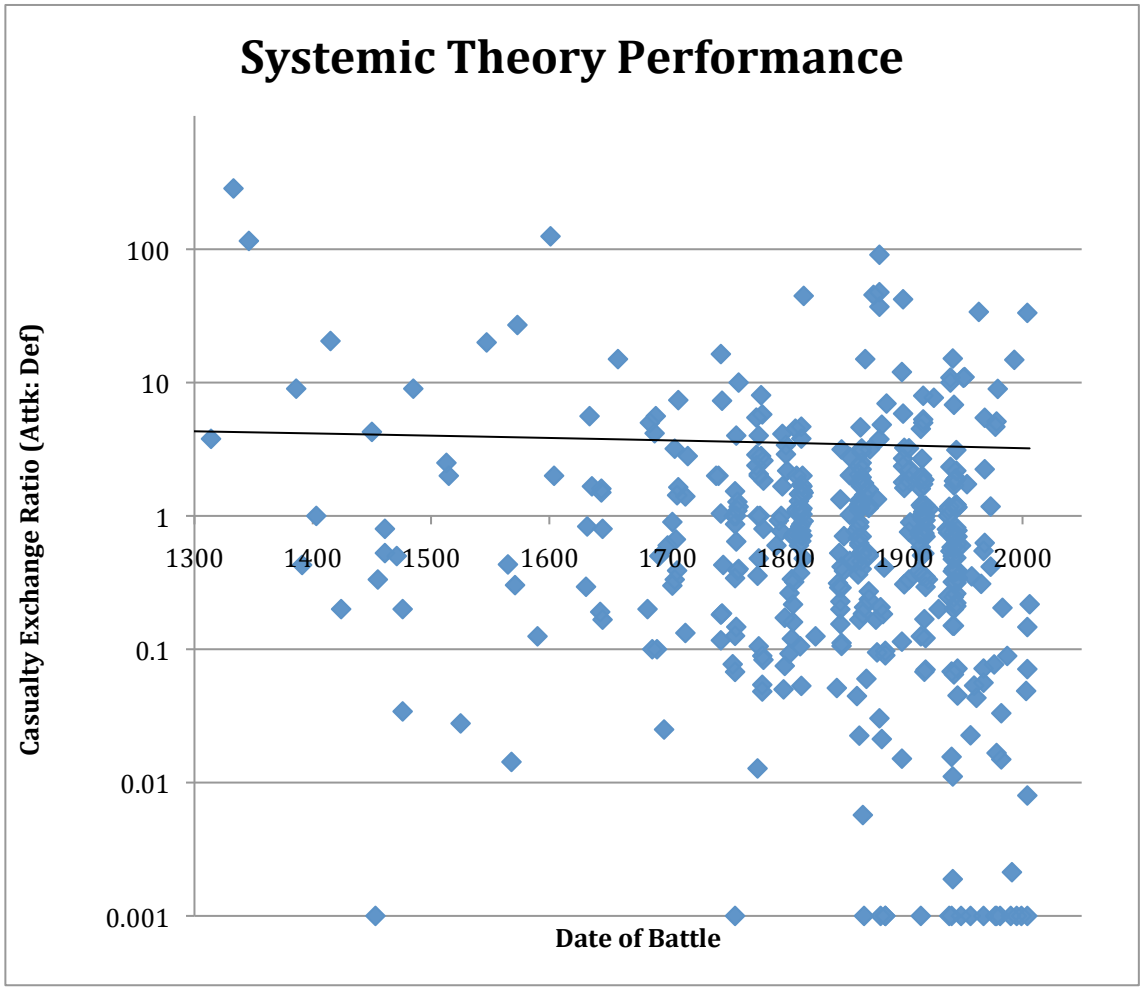
	Total Battles	# of Attacker Victories	% of Attacker Success
1300s	13	7	53.8%
1400s	22	12	54.5%
1500s	14	5	35.7%
1600s	39	23	60.0%
1700s	79	48	60.8%
1800s	159	95	59.7%
1900s	231	153	66.2%
2000s	8	6	75.0%

As with dyadic theory, we can further compare systemic theory's assertions against empirical realities by use of a scatterplot. The expectation here is that the plots should cluster together in any given epoch. For example, in periods where technology favours the attacker, the data plots should cling together for the relevant span of years, relatively high up on the x-axis. In those periods where defensive technology reigned supreme, the cluster of data points should sit lower on the y-axis, reflecting the poorer performance (i.e. higher rate of casualties, in comparison to the defender) attackers achieved amongst technological conditions that challenged their ambition. Every plot along the y-axis above 1.0 indicates a casualty rate which favours defenders (meaning more attackers were lost than defenders). Those plots under 1.0 indicate a

casualty exchange ratio favouring the attacker, with more defenders lost per engagement than attackers.

Unfortunately for systemic technology theory, it appears that not much of a pattern exists. Although the years prior to 0 AD favoured attackers in a relatively uniform manner (a finding consistent with the results detailed above), even this tenuous claim of clustering falls apart as we move towards more recent centuries. From roughly 1300 AD onwards, each point along the x- or chronological axis finds as many battles with casualty exchange rates above the 1.0 line as below. This means that during any given epoch, an attacker had roughly an equal shot of performing well in battle as performing poorly. Technology therefore does little to 'stack the deck' in favour of one strategic posture or another, as the theory claims. Even the slight trend of recent centuries towards a more consistent favouring of offensive postures does little to suggest that as technology changes, battlefield outcomes are dramatically affected in one direction or the other. Systemic theory only holds true if the evidence can demonstrate a consistent favouring of one posture or the other. History, however, does not show that this is the case.

Figure 5.2 Systemic Theory Performance (attacker: defender casualty balance, 1300-present).



The final theory of battlefield victory is combat proficiency. Here the suggestion is that superior military performance is the root of battlefield victory, rather than material numbers or prevailing technology. Albeit imperfect, the measure developed to track proficiency in this study is the *relative loss total*. By examining combat results *per soldius*, this figure controls for inequalities in initial force size, thereby allowing to see how well an army was able to 'punch above its weight'. Moreover, of the 395 relevant battles studied, a striking 78.4% resulted in victory for the more proficient side. Not only is this a much more impressive result than that obtained by the rival preponderance and military technology theories, proficiency's success

appears to be extremely consistent through time—the worst return of victory to a superior casualty balance was no lower than 67% of battles engaged. In other words, even when proficiency demonstrates its least powerful relationship to victory, superior military performance brought victory roughly 7 out of every 10 times.

Table 5.4 Proficiency & Victory Over Time (casualty scores vs RTL).

Epoch	% Proficient Wins			
	Cases	Casualty Score (%)	Cases	RLT (%)
-1500	1	100.0%	1	100.0%
-500	15	93.3%	15	93.3%
500	22	86.4%	23	91.3%
1500	98	84.7%	95	82.1%
1800	139	82.0%	134	76.1%
1900	120	79.2%	52	67.3%
Aggregate	*395*	*82.5%*	*320*	*78.4%*

As impressive as these figures for proficiency theory are, the march of the proficient towards victory is not inexorable. The results for both RLT and casualty scores demonstrate that as the centuries have advanced, so too has the likelihood that the more capable will be defeated. It is possible that proficiency's role has diminished in recent centuries because the grinding attrition that favours preponderance theory has had more opportunity to take effect. Premodern struggles were often characterized by a few pitched battles, followed by swift capitulation or parades through conquered territory. Persia's two offensives against Greece typify such

behaviour. Following his bloody defeat at Marathon (490 BC), Darius I simply turned and went home. When his son, Xerxes, returned in 480 BC, a series of titanic struggles took place, culminating with Salamis (480 BC) and Plataea (479 BC).[496] Once again, a few key, discrete battles determined the campaign's outcome in relatively short order. In contrast, as modernity approached, so changed the nature of battles. Technology, the industrial revolution, and advances in transportation ensured that no longer were battles decisive, single-day engagements, but now had a tendency to transpire over days, if not weeks, and—in the 20thC—for literally months on end. No longer was talent provided relatively singular opportunities to shine, but it was instead subjected to what O'Connell has described as a "perpetual motion machine," one where the great bounty of this economic revolution "was shipped to fronts dedicated to its consumption using the same assembly-line principles by which it was created."[497] The effect was to turn armies "into little more than killing machines."

It appears, therefore, that combat ability is subject to what we have termed 'proficiency erosion.' A succession of bloody contests, such as those witnessed in World War II, can wear down even the most gifted war machines until the point of exhaustion is reached. Endless campaigning plummeted the German army's performance until it was hardly outpacing its rivals. Just as noteworthy is the army of Lee which, withered and hounded on all sides, closed out the US Civil War with a string of performances that were inferior to its rivals—a far departure from earlier in the war. Meanwhile, so too is it possible to overcome technologically-advanced, battle-hardened forces when array against overwhelming opposition. Historically, an army three times the size of its rival can overcome virtually any difference in combat capability. The gifted

[496] Thermopylae (480 BC), and certainly ranks high in the popular imagination, but in terms of total Greeks deployed, it pales in comparison to the truly massive Plataea, where a good 80,000 took to the field.
[497] Robert O'Connell, *Of Men and Arms*, (Oxford: Oxford University Press, 1990), p254.

should therefore always be wary of excessive confidence, particularly when lurking enemies are far more numerous.

Table 5.5 Either Preponderant or Proficient (numerical strength & RLT figures).

Epoch	Total Cases	Superior Proficiency = Victory	%	Preponderance = Victory	Average Preponderance for Inferior Victors
-1500	13	12	92.3	1	14.3
500	15	14	93.3	1	1.4
1500	62	53	85.5	9	2.4
1800	106	75	70.1	31	5.9
1900	53	32	60.4	21	3.2
Aggregate	*249*	*185*	*74.7*	*63*	*2.69x*[498]

This dissertation has shed new light on an interesting series of questions. It has offered a way to consider and test the main theories of battle victory, with several novel and interesting findings being the result. The project has, however, raised as many questions as it has answered. We move now to a consideration of what sorts of implications from the results obtained, and a consideration of where the methodologies, theories, and empirical evidence considered here need to travel next.

5.2 Empirical and Methodological Implications

While the dataset created for this study is the most historical comprehensive that the author is aware of, there are still glaring holes in the empirical collection that need to be filled.

[498] With outliers removed. See below.

The most obvious is the need to expand both the breadth and the depth of the case pool. Battles that have taken place prior to the Renaissance are particularly few and far between. So too are those which have been fought in the non-Western part of the world. Incorporating these missing data points would do much to advance the validity of this study. In addition, there are many battles already within the dataset that remain incomplete. Of the 754 battles, little more than boast all the required information necessary to perform the full suite of empirical tests performed above. Adding the specific data that these lack would go a long ways toward improving our confidence in the conclusions made here.

Perhaps most urgent of this work is the need to fill out the roster of World War I and World War II battles. Given these wars' central role in the 20th century, the fuller an understanding of these dynamics the better our causal appreciation of this century will be. Obtaining such data will not be easy. The most prospective source is divisional deployment figures. Generally, these can be found for most battles.[499] Although no troop strengths are attached (given the great degree of ebb and flow in numbers such organizations endured), we can arrive at rough estimates of battle strengths by multiplying the numbers of divisions per front with typical divisional strengths. This is of course a highly imperfect measurement, but it should provide a useful guide of how many troops were on the field at one time. Knowledge of RLT ratios would be especially useful when considering the evolution of German tactics in the later part of the war. They would help us better understand what is going on, what the impact of Bruchmüller system was, and, ideally, whether or not the Germans had a shot of winning the war. Meanwhile, also needed are more cases from recent times. It will be crucial to add data

[499] The most accessible resources are John Ellis and Michael Cox, *The World War I Databook*, (Aurum Press, 2001); and John Ellis, *The World War II Databook*, (Aurum Press, 2002).

from Iraq and Afghanistan in particular. Doing so will likely require a reliance on primary sources, since secondary battle complications are generally a decade or more behind the present.

Despite this study's assorted methodological innovations for studying and testing theories of battle victory, it has nonetheless illustrated the need for further development of the discipline's methodological toolkit. One of the most urgent tasks will be to arrive at a ratio metric for victory, yet still fall within the geographic interpretation) of what victory actually is. The categorical win/loss variable is unfortunately a bit constraining when performing statistical analyses, and is perhaps a bit imprecise. Are not some victories bigger and better than others? Moreover, the 'relative performance' or casualty balance substitute relied upon here suffers from the fears of tautology outlined above—at least when dealing with RLT measures of combat performance. A newer, more discrete measure will thus have to be developed and then the necessary data collected.

Another methodological challenge will be to find a way to track technology over time. Of the three chief independent variables studied in this dissertation, technology was by far the most onerous one to trace over time. Even if we assume the firepower/mobility dichotomy, operationalizing technology's effects is not easy. We have extensive lethality data, for example, but no measure of what the aggregate impact has been. A suggestion is to look at naval vessels over time. The reason for doing this is that ships offer a straight-forward and consistent weapons system to track over time. Variables like draft, speed, gun complement, and shell size can all be used to track the weapon's evolution. The number of maritime weapons is relatively manageable, and naval engagements are relatively straightforward affairs, at least until time of airplanes. It will take work, however, to determine whether or not ships stand as a useful proxy for the technological balance overall.

Last is a need to look at what lies behind casualty exchange ratios. While they do well to describe overall proficiency performance, they are of little assistance when disaggregating combat performance into its political, strategic, operational, and tactical roots. There is no real way to overcome this failing, except to pursue further qualitative study. Only then can we arrive at a more nuanced understanding of the dynamics that lead to a specific battle outcome. Relative Loss Totals simply do not tell the whole story. In the meantime, however, quantitative examination of proficiency in the vein of this study will at least help avoid *ex post facto* declarations about who was the superior side. Victors have often been lauded with laurels for performance that they have not earned.[500] We must therefore rely on casualty exchange ratios to combat the all-too prevalent assumption that just because a belligerent won, that it displayed superior combat performance. Similarly, the praises of many unfairly maligned armies remain unsung. The Red Army's blitzkrieg of Manchuria is but one example of a case begging for reevaluation. It is the author's hope that other scholars will take up this challenge.

5.3 Theoretical Implications

It is important to ask of any intellectual enterprise the *'so what'* question? Why was it worth doing all of this studying? Has the product of this research moved forward the yardsticks in our quest for a better understanding? Hopefully the reader will conclude the above findings were worthy in their own right. But it is more, however. Novel insights generally inspire as many good questions as they solve, if not more. We move now to a discussion of what arises from the aim to participate fully and constructively in this process.

By dismissing the preponderance hypothesis (at least in its naked form), this dissertation has raised serious questions about the theoretical integrity of realism. After all, what is realism

[500] Hollywood's deep misunderstanding of World War Two is an obvious example. For a related point, see Norman Davies, *No Simple Victory: World War II In Europe, 1939-45*, (Penguin, 2008).

without the assumption that power is both appreciable and certain to prevail in contests with those of inferior strength? As we have seen, the putatively 'bigger battalion' loses all too often. This is not to suggest the emphasis on proficiency uncovered here does away with the notion of power politics; far from it. The proficient are certainly more powerful in that their command of the battlefield is predicated on destroying more of an enemy than they endure in return. What is problematic with realism, however, is how they measure power. Before we can go further, that problem will have to be solved, for raw strength is not nearly as obvious as most realists would have us believe. Moreover, if power is not a matter of troop strength or iron foundries, leaders have been behaving in an 'irrational' manner.

The findings in the technology chapter offer a series of theoretical implications as well. First is how our tour through the literature has shown that technology theory is terribly muddled. Authors tend to use 'core' and 'broad' conceptions interchangeably, and often mix 'dyadic' with 'systemic.' Or they ignore each other's existence. Before the theory can be rebuilt and move forward, its proponents will need to consider what the theory actually is and what it wants to achieve. As it now stands, the word 'technology' is bandied about without due precision to just what type of phenomenon is to explain, and how it does so. Only before the literature sorts itself in regards to these questions can it proceed. Second is the matter of whether or not technology theory can survive the absence of epochal stability? How does the materialist, 'core' conception of technology theory respond to the challenge that there is relatively little deviation in the returns to force posture over time? Attackers tend to win about 60% of the time, regardless of the technological circumstances. Moreover, does this epochal instability have an impact on the broader theory as well? Perceptions of the technological balance need not match material

realities. Leaders may *think* epochs are stable, even when they really are not. But then the theory becomes no longer really a story about technology.

There are numerous theoretical implications stemming from this study's work on proficiency. First is to consider what is necessary to create a *theory* of proficiency, illuminating its key causal mechanisms. What are the causes of proficiency, rather than simply its battlefield effects? And to what extent can the trappings of technology theory that are not actually about technology be incorporated into this theory? Second is the need for an in-depth case study examination, to see how well the idea of proficiency erosion performs under the glare of a single-*n* case. The Great War stands as an excellent candidate for such treatment, since all three theories—preponderance, proficiency, and even technology—are offered as reasons for the war's outcome. It would be an innovative approach to consider this terrible struggle with the idea of proficiency erosion at its core. Third is to look at whether or not the trend of proficiency erosion is likely to continue on. Work here has shown how growth in battle length has corresponded with the industrial revolution, and how this had a profound impact on the potential to wear away the militarily-gifted. What remains to be seen, however, is whether or not the information revolution will have the same or a contradictory effect. Perhaps guerilla campaigns will now last longer, too, because it is possible to keep sending out internet appeals for more recruits. Is proficiency going to make a return in a globalized world? .

Are battles of annihilation more likely than attrition in an age of CNN? Do the new information technologies shape of contours of battle as the emergence of industry did?

The Matter of Mobilization (How Some Erode the Proficiency of Others)

The central lesson of this project has been that while proficiency theory offers a far more persuasive causal explanation for victory than its preponderance and technology rivals, combat

capability is not static. On the other hand, while technology and preponderance theories ignore the institutional conditions that amplify or diminish their performance, so too does proficiency theory overlook the fact that material underpinnings can still play a crucial role in combat outcomes. Proficiency, after all, offers no panacea against superior numbers, at least when confronted with great enough quantities. It can be either overwhelmed—typically when an opposing force is about three times greater—or simply worn down during a steady stream of engagements. Collapses in combat performance, as we have seen, are likely to occur from the loss of talented soldiers to extended campaigning and their replacement with poorly trained levies. In this way proficiency exhaustion can prove deadly. Germany's superiority in arms was sufficient to defeat a preponderant Britain and France in 1940, for example, but not enough when the United States and, particularly, the Soviet Union were added to this equation. The concept of proficiency erosion therefore offers an explanation as to why the talented sometimes lose, but also why numbers can have great effect, if only after a certain point.

This dissertation has told a story of what happens on the battlefield and why. It has made clear which forces are likely to win the engagements they fight, and which are to lose. Armies boasting both preponderance and superior proficiency are almost certain to win; the merely proficient tend to win, on historical average, about 80% of the time; and those who are outfought by their rivals will generally win when they outnumber their opponent by an average of three-fold. The concept of proficiency erosion, however, begs us to consider not only the various roots of combat effectiveness, but also how resources are mobilized over time. Military exhaustion comes when an army's strength cannot keep pace with its enemy's, regardless of relative loss rates. The Red Army, for example, suffered terribly at the hands of the invading *Wehrmacht* in 1941. But it was Germany's proficiency that was ground down as the war progressed, not the

Soviets'. This is because, as we have seen, Zhukov could send relatively fresh—albeit battle-hardened—divisions across the Oder in 1945, whereas the Germans had very little of their vaunted *blitzkrieg* machine left.

This study has shown that numbers matter, even if not in the manner traditionally conceived. If proficiency's endurance potential relies upon both a stock of resource and how well this matches its rivals, we need to consider how these resources come about in the first place. It is therefore incumbent on the researcher to consider the matter of mobilization. Such consideration would allow us to move beyond battle victory explicitly, and into the matter of how battles string together to form wars. More specifically, the concern here takes on two forms. First is the matter of resource availability—how *much* of a given stock of resources exists to be mobilized in the first place—and the efficiency of mobilization, or how *effectively* these resources are harvested. Both play a crucial role in what level of resources a military will have at its disposal. As has been witnessed in cases as historically disparate as the Punic Wars and America's imbroglio in Vietnam, these arrangements will greatly influence outcomes over time. Resource bases and extraction rates allow some armies to sustain numbers in the field (and thereby staunch proficiency erosion through the constant re-supply of fresh, young soldiers[501]). In contrast, others frequently end up with no more blood left to give—either in absolute terms (that is, there are no bodies left to conscript), or a political unwillingness to add further fuel to the fire (such as the US public during the later stages of the Vietnam war). Thus by embracing

[501] On the surface, the addition of young recruits may appear counter-intuitive to the idea of maintaining combat proficiency—for they do not enjoy any battle experience, and thus are simply not as capable as battle-hardened veterans. Nevertheless, the effects of eager young soldiers should not be understated. Even the most experienced (and thus those with the highest potential proficiency) lose effectiveness when facing exhaustion. Lee's ragged Confederate army was poorly supplied and on its last legs in 1865. In contrast, the addition of America's newly formed divisions in 1917 and 1918 offered a huge boon to Entente proficiency during the latter stages of the war, all despite displaying a pronounced greenness and absence of tactical skill equal to their well-experienced French, British, and German counterparts. It was, however, their vigour and eagerness to fight that so impressed observers who had sat amidst four long, bloody years of trench warfare.

proficiency erosion, the battle victory literature can finally begin to address the underlying institutional frameworks that have for so long gone inadequately examined.

Of the two, it is the former that is most obvious. Economic concerns have laid many an army low, given that when lacking resources—both men and materiel—no army can take to the field. By 1944, even the Soviet Union was nearing the end of its once-limitless manpower.[502] The Germans, however, had suffered far worse, losing 1,457,000 troops on all fronts between June 1 and November 30, 1944, leaving few Germans left to fight. For this reason most German officers were aware as they closed out the war that they had no hope. Raw materials, too, are a fundamental element of a sustained war effort. Interwar theorists looking back on the Great War considered how it "brought a rude awakening to the fact that no nation could be sure of a steady supply from abroad . . . As for the Central Powers, the acute shortage of essential minerals which they experienced was a very considerable factor in their ultimate defeat."[503] That such shortages played a crucial role in the inability of the Central Powers to keep up the fight was lost on few.

Just as important, however, is the rate at which the mobilization of said resources can be achieved. Material resources mean nothing if they are left in the ground, or harvested inefficiently. In the 1780s, for example, France could boast a GNP twice that of Great Britain. Even so, because of its more efficient institutions, Whitehall was nevertheless able to collect more taxes than France.[504] Even more dramatic is the growth of mobilization potential that accompanied the French Revolution's "mobilization of belief."[505] France's population did not grow dramatically during this period, but its ability to call men to the colours certainly did. As a

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[502] David Glantz *et al*, *Slaughterhouse: The Handbook of the Eastern Front*, p52. See also von Mellenthin, *Panzer Battles*.
[503] C. K. Leith, "Mineral Resources and Peace," *Foreign Affairs* Vol. 16, (April 1938), p515-24, quote at p515-16. Leith was a major contributor to the interwar debate on the nexus between mineral raw materials and conflict; see his, *World Minerals and World Politics: A Factual Study of Minerals in their Political and International Relations*, New York: McGraw-Hill, 1931.
[504] Ferguson, *Cash Nexus*, (New York: Basic Books, 2001), p94.
[505] MacGregor Knox and Williamson Murray, *Dynamics of Military Revolutions*, (University of Kansas), p10.

consequence, the 'levee en masse' declaration during the early days of the French Republic brought a three-fold increase in the army in under a year.[506] By mid-1794, France could put an astounding 750,000 men in field[507]—a figure nearly double that of Louis XIV a century and a half earlier. On the other hand, decisions can trap mobilization at low rates. Grant was skeptical of the black troops in his Civil War army.[508] Such wariness that did not improve much during the First and Second World Wars, and lessened America's potential frontline strength. Germany's highly inefficient use of female workers in World War II was a similar waste of precious labour, particularly in contrast to the Allies' vast incorporation of women into their economies. What matters is therefore more than just raw numbers. One may boast a massive material base, but then limit the efficiency of use. If anything, this study has raised good reason to consider these questions.

The Malleability of Proficiency

A second avenue for future research is to determine just how malleable proficiency is. Armies can improve with training and time. In its wars with Carthage, for example, Rome constructed an entirely new navy—indeed, it fashioned itself into a naval power. Similarly, America was able in the Great War to construct a relatively impressive, continental-sized military force almost from scratch. On the other hand, so too can military potency evaporate over time. As Keeley notes, "Military ferocity is not a fixed quality of any race or culture, but a temporary condition that usually bears the seeds of it[s *sic]* own destruction."[509] Germany is currently more concerned with making cars than tanks, and the Japanese with consumer

[506] Knox and Murray, *Dynamics*, p8.
[507] Knox and Murray, *Dynamics*, p65-66.
[508] Knox and Murray, *Dynamics*, p80.
[509] Lawrence H. Keeley, *War Before Civilization: The Myth of the Peaceful Savage*, (New York: Oxford University Pres, 1996), p130.

electronics than carrier aircraft.[510] Today the Navajo are better known for ornate silverwork and fashionable rugs than their once-considerable military prowess. What drives this growth? What drives this decline? Why and when do even the most hardened warriors become pacific?

These dynamics remain poorly understood. A better understanding of this process will require a de-tangling of proficiency from its political, strategic, operational, and tactical roots. For example, crucial at the political level will be consideration of the forces of national urgency and the legitimacy of leadership. It may be that how hard an army fights is partly a reflection partly of whether or not the struggle is about a national survival. It may also be that unpopular regimes find it difficult to mobilize forces and to have them fight well. At the operational level, we can look at the efficiency of institutions, for how they translate raw potential into exploitable material will play greatly into the story of proficiency erosion told above. Great Britain, for example, was able to borrow more much more cheaply than Napoleon, a fact that permitted the much smaller British economy to keep pace with its continental rival. Similar questions can be asked of the strategic and tactical roots of proficiency as well. Much of their story remains to be told, certainly now that we know how crucial proficiency is to battlefield victory.

5.3 Policy Implications

The conclusions arrived at in this study lead to several policy implications. The first lesson is that numbers, in and of themselves, are no reliable basis for strategy.[511] History has not been kind to inept or mishandled armies, no matter how large. The Soviets, for example, sent in

[510] This is not to suggest that either case lacks military acumen. It does not, however, boast nearly the same military potential as it did in the 1930s and 1940s.

[511] Another policy implication from the preponderance results is that a faith in superior numbers—long held to be a country's surest form of military security—is in fact little insurance policy at all. Assuming that numbers are what matters most in military affairs leads to the arms racing dilemmas that preceded the First World I. Although such insecurity spirals are conditions are not guaranteed to end up in violence, they do much to poison relations between nations. Perhaps the broader lesson, then, is that when it comes to war, do not trust folk wisdom, no matter no long this truism has endured.

ever-longer columns of tanks and infantry during their 1979-1989 occupation of Afghanistan. But no matter how much this deployment escalated, ultimate victory remained outside Moscow's grasp. The relevance to today should be similarly telling, for 'troop surges' alone are not likely to bring the West victory in places like Iraq and Afghanistan. Instead, any additional troop deployment must be accompanied by a concerted plan to not only bring decisive strategic effect against the enemy, but to have these additional numbers *improve an army's ability to do so*. In other words, the impact of additional troop strength must be felt in an exponential fashion. Bigger armies need to be force multipliers. Without that dynamic, the tendency instead is to face what economists term diminishing marginal returns. The needless weight will simply lead an army to lumber about unproductively, and therefore help bring about defeat that much easier. Ultimately, military size means nothing in the absence of strategic direction and a capacity to put it into practice.

A second suggestion deals with the matter of technology. It is the advice of extreme caution. True, the gifts of the engineers can be extremely useful on the battlefield. No one will deny the handiness of the Predator drone to US forces or the Improvised Explosive Device to the Taliban insurgent. But technology alone does not transform the battlefield. For example, with the exception of artillery the Napoleonic wars were fought with the same technology as those of Frederick the Great. A technologically-deterministic view of these cases would thus anticipate little distinction in the wars of one compared to those of the other. Yet the ideas and politics of these two ages were sharply different.[512] Consequently, the shape of the war in these periods could not have been more different. "In the two thousand years of recorded world history, so sharp a revolution in customs, ideas, and beliefs has perhaps never occurred before." Almost overnight, the art of warfare had been turned upside down. "By a canny combination of patriotic

[512] Knox and Murray, *Dynamics*, p62.

fever, massive conscription, enhanced mobility, and industrial-scientific effort the armies of revolutionary France swept the forces of the *ancien régime* from the field."[513] In this, technology played only a subsidiary role. "Above all, the political aspects of warfare had been totally revolutionized. The old regime subject now became an active citizen, one who owed the nation military service. In return, the nation trusted the *citoyen* sufficiently to place arms in his hands."[514] Millions were called to the colours in consequence, resulting in a remarkable impact on the battlefield; whereas the French army was comprised of one soldier for every 150 inhabitants in 1740, that figure had dropped to just one in 50 by the early 1790s.[515] Army size burgeoned in consequent fashion. Indeed, with this remarkable abundance of troops, the great armies of the age battled each other with scale and duration that Frederick and his contemporaries could have scarcely imagined. The *Grande Armée* that battered its way to the Kremlin started out 500,000 strong. Louis XIV (1638-1715), in contrast, could not boast a field army much larger than 100,000.[516] Thus technological change appears to be unnecessary to dramatically transform the battlefield. Instead, it was only when technology was harnessed to a concrete strategy or a set of *ideas* that change took off. Ideas are therefore the most crucial component.

Another way of looking at this is how, as John Ferris has observed, while technology may serve to multiply one's strength, it does not necessarily decrease one's weaknesses.[517] Power must therefore always be directed by strategy to overcome these shortcomings. A prudent

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[513] Christon I. Archer, John R. Ferris, Holger H. Herwig, and Timothy H.E. Travers, *World History of Warfare*, (Lincoln: University of Nebraska Press, 2002), p404.
[514] Archer *et al*, p404.
[515] Theodore Ropp, *War in the Modern World*, (London: Collier Books, 1962), p45; and calculated from Paul Kennedy, *Rise and Fall of the Great Powers*, (New York: Random House, 1987), p131-2.
[516] Michael Doyle, *Ways of War and Peace*, (New York: W.W. Norton, 1997), p176-77.
[517] John Ferris, ""Conventional Power and Contemporary Warfare", in John Baylis, James J. Wirtz, Eliot A. Cohen, Colin S. Gray, *Strategy in the Contemporary World: an Introduction to Strategic Studies*, (Oxford, 2010), p254. Ferris was looking at the Revolution in Military Affairs (RMA), but the principle applies more generally as well.

policymaker would be wise to remember that although the French chassepot was a better rifle than the Prussian needle gun, it did not prevent the calamity of Sedan (1871). The story of technology is thus that money cannot ensure victory. Technology is useless without a suite of associated, useful tactics. Indeed, victory is not so much a matter of an improved raw capacity to kill, but rather being able to capitalize on whatever weapons are available, by hurting the enemy without enduring concomitant casualties in return. Nor do you even need technology to kill. The Rwandan genocide, for example, extinguished human life at a place at least five times that of the Nazi death camps.[518]

The findings regarding proficiency lead to a series of policy implications as well. Perhaps most obvious is the concomitant suggestion that militaries focus their military spending not on military capabilities *per se*, but rather with a close eye towards facilitating their operations. That may entail the purchase of capabilities like tactical helicopter transport, strategic airlift, and stand-off weaponry. But more urgent is the relentless training and sustenance of troops themselves. Indeed, the purchase of a purely 'prestige' item like an aircraft carrier, for example, is impractical—if not entirely wasteful—if not accompanied by complementary naval capabilities. Absent anti-submarine warfare (ASW) escorts, for example, carriers sink quickly. Getting this mix of proficiency-improving, integrated capacities right requires, in turn, a strict definition of the missions and goals a political leadership wants their military to undertake. Cultivating proficiency relies upon a strong understanding of what types of battles an army is going to find itself engaged in. Lacking such certainty, effective preparation becomes extraordinarily difficult.

[518] Manus I. Midlarsky, "Identity and International Conflict," in Manus I. Midlarsky, (ed), *Handbook of War Studies II*, (Ann Arbor: University of Michigan Press, 2003), p40.

Meanwhile, above all else, both political leaders and generals must also remember that no matter how good one's army becomes, sometimes talent is not enough. Despite the crucial role combat performance plays with battle victory, material factors cannot be ignored. Indeed, one of the great and terrible lessons of World War I was that the prewar emphasis on individual combat ability—particularly regarding courage and élan—paid few dividends. This was not for a lack of popularity of the idea. Morale arguments like that of du Picq were held in great esteem, seduced by the idea that:

> "The art of war is subject to many modifications by industrial and scientific progress. But one thing does not change, the heart of man. In the last analysis success in battle is a matter of morale. In all matters which pertain to an army, organization, discipline and tactics, the human heart in the supreme moment of battle is the basic factor."[519]

This emphasis on individual troop qualities was certainly reflected in the doctrine of the time. The French Army Field Service Regulations of 1895, for example, ordered that:

> "Combat has for its end to break by force the will of the enemy and to impose on him our own. Only the offensive permits the obtaining of decisive results. The passive defence is doomed to certain defeat; it is to be rejected absolutely…At a signal from the Colonel the drums beat, the bugles sound the advance and the entire line charges forward with cries of *en avant, à la baionette!* ['forward, with bayonets fixed!']."[520]

Across the Channel, similar thinking had taken hold. Sir Ian Hamilton concurred with the individual morale argument.

> "Blindness to moral forces and worship of material forces inevitably lead in war to destruction…All that trash written by M. Bloch before 1904 about zones of fire across

[519] Colonel Charles Ardent du Picq, *Études sur le combat*, (1880). Cited in M.J. Cohen and John Major, *History in Quotations*, (London: Cassell, 2004), p699.
[520] Cited in Hew Strachan, *European Armies and the Conduct of War*, (1983), p105, 116.

> which no living being could pass, heralded nothing but disaster. War is essentially a triumph, not of a chassepot over a needle-gun, not of a line of men entrenched behind wire entanglements and fire-swept zones over men exposing themselves in the open, but of one will over another weaker will."[521]

The irony of such a statement, however, is that Hamilton later commanded the Anglo-French disaster at Gallipoli (1915). There, in the rocky shores of the Dardanelles, Turkish positions could not be broken, no matter how great the bravery and courage the attacking soldiers were. The French, British, Australians, and New Zealanders were proud, loyal, and resolute in the face of horrendous conditions. Yet even the most desperate heroism could not save the Entente from ignominious defeat.

Proficiency in an Age of Great Power Rivalry

US defence planners certainly hope proficiency is able to maintain its edge. America's preeminent position in the international system is, after all, maintained in large part by a military far qualitatively superior to any of its rivals—or even a combination thereof. Even when facing a rapidly growing China, America's superior combat capability is assumed to be sufficient to keep the prospective rival at bay, at least vis-à-vis US interests. In effect, the assumption is that US talent will hold off Chinese numbers. The same concept guides American efforts in Iraq and Afghanistan, where the responsibility for pacifying large countries and tens of millions of people rests on the smooth, competent integration of Stryker brigades, special forces, drones, and

[521] Sir Ian Hamilton, *Compulsory Service*, (1910), p121-2. Hamilton was speaking of I.S. Bloch's *Is War Now Impossible?*, (1898), which (quite presciently) observed that "Every body of men appointed for defence…must immediately entrench itself…Sheltered behind such works, and in a position to devote all their energy to fire against the enemy, the defenders will sustain losses comparatively slight…while the attacking bodies will be exposed to the uninterrupted fire of the defenders, and deprived almost of all possibility of replying to their fire…The attacking army will have to deal with auxiliary obstacles…obstructions formed of beams, networks of wire, and pitfalls. To overcome these obstacles great sacrifices must be made. (p11). Of this, only Bloch's anticipation that defender's casualties would be minimal proved to be erroneous in the Great War. Everything else came to pass.

Hellfire missiles. What if, however, the relative importance of proficiency continues to decline? What if the faith in the superior combat power of Western forces has been misplaced? Alternatively, is it possible that the rise in preponderance theory's explanatory power was simply an industrial phenomenon, and not a *post*-industrial one, and therefore will soon be reversed? To uncover the likely direction future trends will take requires a more nuanced and time-specific examination than the one advanced in this study.

5.4 Final Thoughts

Caveat: Battle Victory is Not Peace Victory

For all the importance ascribed to battle victory in this study, winning battles—and even wars—is not the same thing as winning the peace.[522] While battles are of course a crucial component—there can be no victory without tactical success—their role is as a necessary variable, not a sufficient one. "The winning of battles, even to the point where military events seem to be concluded victorious, is not the same as winning a war, though it is certainly a helpful enabler. War is a political, social, and cultural phenomenon, not only a military one."[523] It is an all-too-common error "to mistake military victory for political victory."[524] As Orr notes,

> "war is won, or lost, in two phases—military outcomes on the field of battle, and the battle to win the peace through reconstruction and reconciliation afterward; what is won

[522] Mandel useful disaggregates the concept of winning into two parts: "war winning" and "peace winning." The latter can be alternatively termed "stabilization, reconstruction, post-conflict transition, or Phase IV operations." Mandel, *Foundations of Victory*, p13.
[523] Colin S. Gray, *Another Bloody Century*, p101.
[524] Hanson W. Baldwin, *Great Mistakes of the War*, (New York: Harper and Brothers, 1950), p107-8.

on the battlefield can be lost entirely thereafter if the countries attacked are not turned in to better and safer places."[525]

The results of this study should therefore be considered with great caution. The conclusions should not be used as a call for the proficient to begin attacking the weak. Doing so would be not only morally improper, but also to be ignorant of the complexities of war. All policymakers, both civilian and military alike, must recognize that "victory is not assured when the shooting stops."[526] To assume otherwise is foolhardy. Policy makers should therefore approach the matters of war and peace with great care and trepidation. One would do well to remember Wellington's words of caution: "I have fought a sufficient number of battles to know that the result is never certain, even with the best arrangements."[527]

A Final Plea

To historians, war is an art, not a science.[528] It cannot therefore be broken down into clear patterns or mathematical models as is a phenomenon in the physical sciences. Sun Tzu offered a similar reservation. 'In the art of war," he wrote, "there are no fixed rules.' Clausewitz, too, shied away from adoption of absolute conclusions. For him war is a collision of two living masses, and therefore unpredictable. The implication was clear:

"[Theory] must also take the human factor into account, and find room for courage, boldness, even foolhardiness. The art of war deals with living and with moral forces. Consequently, it cannot attain the absolute and certain."[529]

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[525] Robert C. Orr, "After the War, Bring in a Civilian Force," *International Herald Tribune*, April 3, 2003, p8.
[526] Steven Metz and Raymond A. Millen, *Future War/Future Battlespace: The Strategic Role of American Landpower*, (Carlisle Barracks, PA: US Army War College Strategic Studies Institute, 2003), p22.
[527] Quoted in G.F.R Henderson, *The Science of War: A Collection of Essays and Lectures, 1892-1903*, Neill Malcolm (ed), (London: Longmans, Green 1905), p44.
[528] For example, David Chandler, *The Art of Warfare on Land*.
[529] Carl von Clausewitz, *On War*, trans. Michael Howard and Peter Paret, p15. See also John Alger, *The Quest for Victory*, (Westport, CN: Greenwood Press, 1982), p186-7.

Despite the immense debt this paper owes to both the field of historiography as well as these titans of military scholarship, the argument advanced here is that such a position is far too severe. Instead, we should remember that while the tools of social science may be imperfect, they provide a handy means of improving the rigour of our thinking, the discipline of our data collection, and the quality of our analysis.

> "After Newton's great discoveries, which had revealed the laws ruling the physical universe, interest focused on finding those which would determine social life. Thus even the power struggle among states was considered to have its laws. The attempt to discover these laws, though condemned to futility because of an erroneous belief in the rationality of human society, resulted in a clear insight into the nature of diplomacy and in a sharper definition of its tasks."[530]

While the 'fog of war' may cloud the most rational calculations and dull the sharpest purposes, it cannot eliminate the underlying factors that influence conflict and provide it some manner of periodicity. There are rules to war, and while some may be bent or even broken, their influence is undeniable. This project has sought to make that fact explicit.

[530] Felix Gilbert, *To the Farewell Address: Ideas of Early American Foreign Policy*, (Princeton: Princeton University Press, 1961), p92.

Appendix: Additional Tables

Table A.1 Biddle's Systemic Technology Periodization (dominant weapon, by period).

Period	Dominant Weapons System	Aggregate Balance
1900-24	Machine gun, barbed wire, and long-range artillery	Defence
1925-49	Appearance of tank, the airplane, and the radio	Attack
1950-74	Maturation of tank, the airplane, and the radio	Attack (very suited)
1975-00	Precision-guided antitank and anti-aircraft missiles	Defence

*Biddle, *Military Power*, p23, 251 fn45.

Table A.2 Van Evera's Offense-Defense among the Great Powers (by period).

Era	Military Realities Favoured	Military Realities were thought to favour	Diplomatic realities favoured	Diplomatic realities were thought to favour	In aggregate military and diplomatic realities favoured	In aggregate military and diplomatic realities were thought to favour	Amount of warfare among great powers
Pre-1792	Defs	Defs	Med	Med	Med	Med	Medium
1792-1815	Aggrs	Aggrs	Med	Aggrs	Aggrs	Aggrs	High
1816-56	Defs	Defs	Defs	Defs	Defs	Defs	Low
1856-71	Med	Med	Aggrs	Aggrs	Aggrs	Aggrs	Medium
1871-90	Defs	Med	Defs	Defs	Defs	Defs	Low
1890-1918	Defs	Aggrs	Aggrs	Aggrs	Defs	Aggrs	High
1919-45	Aggrs	Mixed	Aggrs	Aggrs	Aggrs	Aggrs	High
1945-90s	Defs	Med	Defs	Defs	Defs	Defs	Low

*Steven van Evera, "Offense, Defense, and War," in Michael E. Brown et al (eds), Offense, Defense, and War, (Cambridge, MA: MIT Press, 2004), p246.

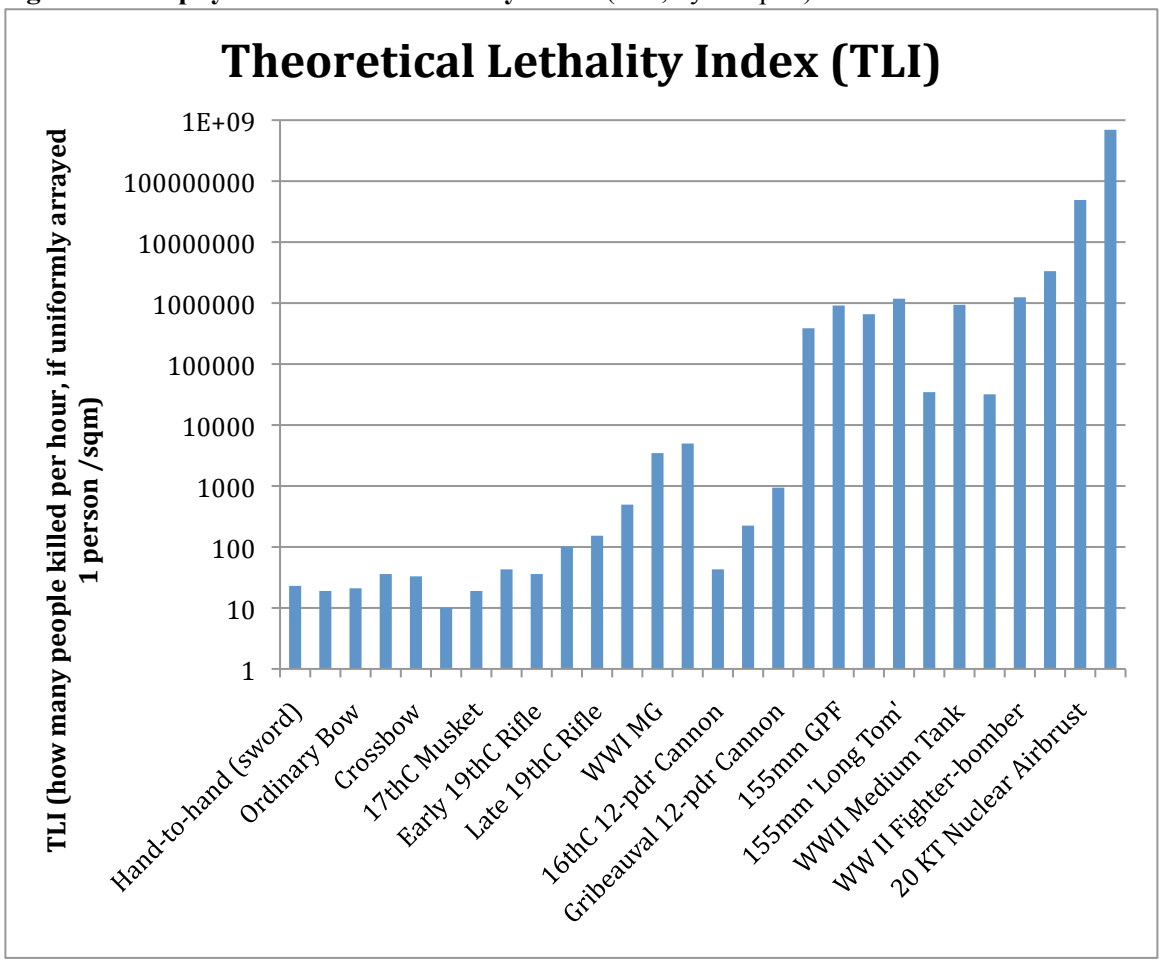
Table A.3 Adams' Systemic Technology Periodization (dominant weapons trends, by period).

Lethality	Protection	Mobility	Overall Offence-Defence-Deterrence Balance
1800-1945	1800-49	1800-35	1800-49
no mode dominant due to the absence of an absolute weapon and the ability of both attackers and defenders to use state-of-the-art weapons, depending on their ability to protect and deliver them.	offence dominant due to the lack of defensive lethality and agricultural and industrial technologies facilitating offensive depth.	offence dominant due to the lack of defensive lethality and improvements in mobile artillery.	offence dominant
		1836-1929	
		defence dominant due to	

		the invention of telegraph, railroad, and steamship.	
	1850-1933		1850-1933
	defence dominant due to the lethality afforded by the conoidal bullet and later advances in firearms, as well as improvements in fortification technology.		defence dominant
		1930-45	
		offence dominant due to improvements in tanks, planes, and especially radio	
	1934-45		1934-45
	offence dominant due to the development of well-armed and armoured tanks and dive bombers.		offence dominant
1946-present	1946-present	1946-present	1946-present
deterrence dominant due to the absolute nature of nuclear weapons.	deterrence dominant due to the lethality of nuclear weapons and the ease with which they can be hidden, delivered, and produced.	deterrence dominant due to the small size of nuclear weapons and the variety of means for delivering them.	deterrence dominant

*Karen Ruth Adams, "Attack and Conquer? International Anarchy and the Offense-Defense-Deterrence Balance," in Michael E. Brown et al (eds), *Offense, Defense, and War*, (Cambridge, MA: MIT Press, 2004), p415. 'Mixed' periods of 1836-49 and 1930-33: gave greater weight to protection than mobility because mobility has little utility if soldiers, weapons, and societies cannot be sheltered from defensive, offensive, or retaliatory strikes.

Figure A.1 Dupuy's Theoretical Lethality Index (TLI, by weapon).



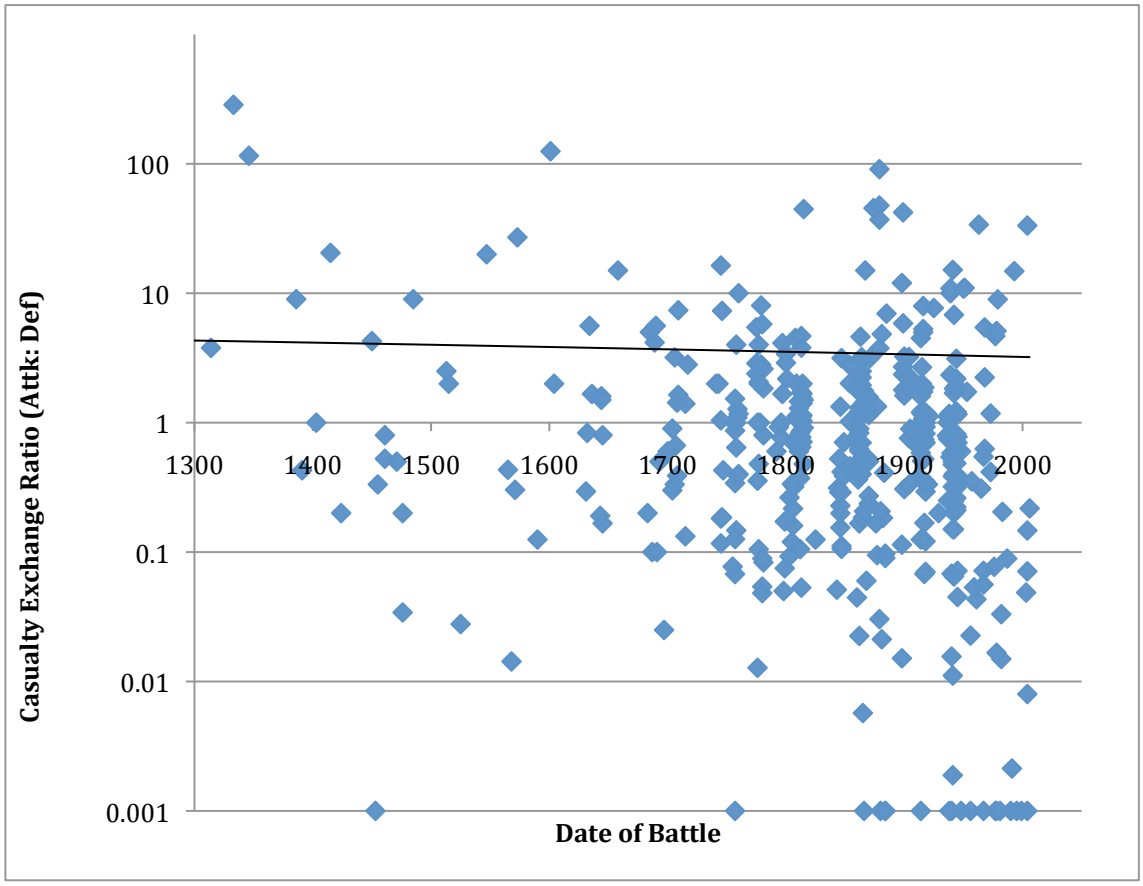
*See Trevor N. Dupuy, *Attrition*, (Falls Church, VA: Nova Publications, 1995), p26-27.

Table A.4 Lethality Trends of Ground Armies (TLI, vs dispersion).

Typical Army of 100,000	Lethality TLI in mils	Men/km2
Antiquity	2	100,000
Napoleonic Era	5.5	4,970
Amer Civil War	14.3	3,883
WWI	233	2,222
WWII	1,281.00	404
1973 Oct War	1,650.00	36
Europe, 1985-90	4,098.00	29

*See Dupuy, *Attrition*, p35.

Figure A.2 Systemic Theory Performance, Recent Centuries (casualty exchange ratios, by battle data).



*Based on 425 battles, ranging from Bannockburn (1314) to Lebanon (2006).

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