'The Sky's the Limit': A Comparative Assessment of the Global Proliferation of Military Airpower in the Early and Late 20th Century

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Abstract of Dissertation

'The Sky's the Limit': A Comparative Assessment of the Global Proliferation of Military Airpower in the Early and Late 20th Century

The purpose of this dissertation is to compare and assess the national-level determinants of military airpower diffusion in the early and late 20th century. To do so I look at the invention of military airpower, its initial adoption patterns, and the intensity of adoption over time. I find that there are two principal determinants of airpower diffusion. The first, and most consistent, determinant is resources, specifically national levels of military power. States with high levels of military capability, as determined by the Composite Index of National Capability (CINC) score, are more likely to adopt airpower earlier and with greater intensity. The second determinant, national status, has had a more complex effect on airpower diffusion. In the early 20th century national status, or a desire to adhere to the norm of technological modernity, increased the speed and intensity with which states adopted airpower. In the late 20th century, though, pressure to acquire airpower capabilities for status purposes no longer held. Instead, it appears that states concerned about their relative levels of status became slightly less likely to pursue airpower.

I also find that external threats are an important underlying cause for increasing airpower adoption intensity, that population constraints affected airpower adoption in the late 20th century, and that among the very earliest airpower adopters the presence of public advocacy groups in favor of aviation increased the rate of airpower adoption. In both the early and late 20th century the airpower diffusion process was facilitated by diplomatic communication channels which allowed for the rapid dissemination of information on aircraft performance and capabilities. These findings are synthesized into two proposed models of airpower diffusion in the final chapter. These models are intended to guide future research into military innovation diffusion.

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Chapter 1: Introduction

The purpose of this study is to answer a few simple questions: why do states rely on airpower? What factors determine the degree to which states pursue airpower capabilities and how have these factors changed over time? And lastly, how has the innovation of military airpower diffused across the international system over the course of the 20th century?

The genesis for this project began with an article in the Wall Street Journal in late September 2011 outlining a proposal by the Iraqi government to spend $4.2 billion to acquire 18 F-16 fighters from the United States. The official justification for the purchase claimed that these aircraft would strengthen the Iraqi Armed Forces and enhance their ability to "protect Iraq's sovereignty and security" against national security threats.[1] I lingered on this statement. Finally, after a few moments of silence, I wondered aloud, "what threats, exactly, are they defending against?"

At the time, the Iraqi government was involved in a life or death struggle against a deadly domestic insurgency that had been raging, at varying levels of intensity, for some seven years. It seemed abundantly clear that the primary challenge to the Iraqi government came not from traditional nation-state actors, but rather from its own population. Specifically, the insurgents' blatant disregard for the state's proclaimed monopoly on the use of force was eviscerating the legitimacy of the national government and the political leadership. The severity of the challenge was obvious, and yet, in allocating limited defense resources, the Iraqi Defence Ministry was choosing to devote

[1] Adam Entous and Nathan Hodge, "Iraq Buys F-16s, Strengthening its Air Force," *Wall Street Journal* (27 September 2011). Accessible at: http://online.wsj.com/news/articles/SB10001424052970204422404576594900420928050. See also "U.S. Says Iraq Agrees to Buy American Fighter Jets," *USA Today* 27 September 2011. Accessible at: http://usatoday30.usatoday.com/news/world/iraq/story/2011-09-27/iraq-us-fighter-jet/50567544/1

billions of dollars to a weapons platform that is largely ineffective, and possibly counter-productive, in urban counterinsurgency operations.[2]

Broadening the aperture we find that reliance on airpower as a means of countering domestic insurgent opposition is actually quite common, despite its relatively poor track record (Kocher et al. 2011). For instance, in 2012 the small African nation of Uganda signed an agreement with Russia for the delivery of 6 advanced SU-30MK2 fighter aircraft even though the country's primary enemy, the Lord's Resistance Army (LRA), is a domestic insurgent group that operates almost exclusively in the mountainous, forested areas of northern Uganda and South Sudan.[3] In these areas, aerial observation of LRA forces is difficult, nay impossible, particularly from aircraft designed to fly at twice the speed of sound. Another example comes from Gaza where Israel has been conducting airstrike counterinsurgency for years. Despite sustained periods of aerial bombardment, rocket attacks out of the Hamas-controlled enclave continue with regularity.[4] Even in Afghanistan where the United States and its allies have brought to bear one of the largest, most sophisticated aerial armadas in history, insurgent forces have yet to be defeated. After 13 years of war the Afghan conflict has shown that Western airpower may be capable of suppressing insurgent forces for a time but is, in the end, incapable of eliminating insurgent opposition (Lyall 2013).

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[2] I recognize that precision guided munitions (PGMs) have made the fast attack aircraft far more useful in counterinsurgency campaigns. But capitalizing on this advantage by destroying insurgent strongpoints while avoiding counter-productive and morally reprehensible collateral damage requires high levels of tactical awareness, personnel proficiency, inter-service communication, and technical skill. The United States military possesses all of these traits and still struggles to carry out this task effectively. To assume that the infant Iraqi armed forces are capable of such sophisticated operations is simply unrealistic.

[3] Ismail Musa Ladu, "Russia Says Uganda to Buy Six More Jets," *Africa Review* (24 September 2012). Accessible at: http://www.africareview.com/News/Russia-says-Uganda-to-buy-six-more-jets/-/979180/1515754/-/13bxtp3z/-/index.html

[4] "Israel Bombs Gaza after Rocket Attacks, Hamas Gunman Killed," *Reuters* (29 June 2014). Accessible at: http://www.reuters.com/article/2014/06/29/us-israel-palestinians-idUSKBN0F40FC20140629

So, again, given the enormous costs associated with acquiring and operating combat aircraft[5] and their inherently limited utility in counterinsurgency conflicts, why do states continue to acquire airpower assets? Looking across the range of states in the international system, what national factors determine levels of commitment to airpower strategies more generally? Historically, how has airpower been received by national leaders, and how have perceptions of, and reliance on, military airpower changed over time?

I. Airpower Diffusion and its Implications

Throughout history states have sought to dominate one another through the use of organized violence. Up until the 20th century, force was asserted via land-based and sea-based military forces. The employment of aircraft for military purposes in WWI, and the further refinement of aerial attack strategies and tactics in WWII, altered the nature of warfare. Today airpower is a major component of broader military power, one that is widely available and distributed across the international system (See IISS 2013). But airpower suffers from a distinct disadvantage relative to land-based power. All states require soldiers on the ground for two things: maintaining civil order and, in the case of war, invading and occupying enemy territory. The former is necessary for establishing domestic political legitimacy; the latter for deterring potential enemies from attacking. Both roles are fundamental to national defense and required for state survival. Both roles are fulfilled by the Army in most cases, or for island nations, the latter is fulfilled by the Navy.

An Air Force can assist in these roles but by itself can neither contain domestic political unrest nor threaten to occupy foreign territory. Airpower is capable of

[5] A single F-16, considered a relative bargain among modern attack aircraft, costs around $19 million for the airframe alone and $4-8 million a year to operate (Wheeler 2011).

supporting and enhancing these basic Army functions but it cannot on its own supplant land-based forces. As such, an Air Force can be viewed as something of a supplemental force, one that augments the capabilities of its sister services but is incapable of achieving victory independently.[6] Thus, the decision to devote precious defense dollars toward airpower represents a distinct trade-off in defense policy, not one between "guns and butter" but rather one between different types of "guns". This means, of course, that airpower adoption is a political decision born out of an overt policy choice rather than an innate military necessity. Understanding how these choices are made, and what military force structures result, has several implications on international relations scholarship.

For example, in recent years international relations scholars have begun to look at military force structures and their influence on conflict outcomes. Particular attention has been paid to unconventional warfare and the effectiveness of various weapons and tactics in counterinsurgency operations. Lyall and Wilson find, for instance, that the increasing mechanization[7] of state militaries over the 20th century has adversely affected the success of counterinsurgency campaigns (2009). They argue that heavily mechanized government forces distance themselves from the local population. This distance inhibits tactical intelligence collection and creates difficulties when trying to win the support of the populace. This, in turn, weakens the government's ability to identify and eliminate insurgents and their sympathizers. Ultimately, high levels of mechanization degrade the government's ability to conduct effective counterinsurgency operations leading to high rates of mission failure.

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[6] There is, of course, a mass of literature debating the potential and limits of aviation is a war winning weapon. For a review see Byman and Waxman 2000 and Lambeth 1997.

[7] Mechanization refers to a greater reliance on military vehicles like armored personnel carriers and tanks over individual soldiers.

The inverse relationship between mechanization rates and counterinsurgency success is very much an extension of the debate over U.S. tactics in Vietnam. Krepinevich argues, for instance, that the failed pacification campaign by the U.S. Army in South Vietnam was due to the Army's preference for overwhelming firepower over discriminant force (1988). Reliance on overwhelming firepower led to high civilian casualties which, ultimately, undercut the government's attempts to gain the support of the citizenry. In Vietnam one of the primary vectors for delivering this overwhelming firepower was airpower. Indeed, policymakers at the highest level in Washington were directly involved in the air campaign, individually selecting targets for attack in the North and approving the use of aviation assets on a broad scale in the South (Randolph 2007). Despite the enormous effort involved, the air campaign was ultimately unsuccessful, and possibly counter-productive, particularly against the Vietcong (Clodfelter 1989).

The questionable effectiveness of capital-intensive force structures (mechanized and aviation forces included) has led many to ask why states continue to rely on these methods of military organization. In order to address this issue several scholars have begun looking at variation in the national determinants of military forces structures. For example, Sechser and Saunders find that strategic factors, namely a recent history of militarized disputes and heavily armed neighboring states, encourage high levels of military mechanization (2010). They find these results hold steady across a range of states (153) over a long period of time (1979-2001).

Other scholars challenge these findings. Gartzke argues, for instance, that domestic political institutions, specifically democratic governance systems, encourage capital over labor-intensive force structures (2001). Caverley supports Gartzke's claim, finding that democratic states engaged in counterinsurgency conflicts are more willing to invest in capital-intensive force structures *even if their performance is inferior* (2010).

This non-strategic behavior stems from an aversion to military defeat and a willingness to accept capital losses over human losses. Ultimately, in democratic states, voters support "the use of capital-intensive doctrine in conflicts where its effectiveness is low because the decreased likelihood of winning is out-weighed by the lower (human) costs of fighting" (Caverley 2010, 119). Finally, still others argue that the development of capital-intensive force structures, particularly the acquisition of expensive military equipment, is driven by normative processes. Eyre and Suchman find, for instance, that highly institutionalized weapons, those items that carry a high degree of symbolism, are often acquired not for their practical utility in national defense but rather for their contribution to national status (1996). In this case, irrational force structuring decisions, which may very well impact actual defense capabilities, are based on normative pressures from the wider international community rather than strategic calculations.

Focusing this study on military airpower allows me to contribute to the broader conversation. By looking at a form of military power that is both capital-intensive and inherently undiscriminating, I can test the competing explanations for force structuring behavior – both strategic and non-strategic. This study ultimately advances our knowledge of how states structure their military forces, how these factors compare across eras, and what conditions favor one particular approach (strategic, domestic, symbolic, etc.) over the others. Finally, the greatest contribution comes from the proposal of a new model of military airpower adoption, one that can be applied to additional military innovations in order to guide future research on military force structure decision making.

II. Airpower Definition

Historian Jeremy Kinney defines military airpower as "the use of military aircraft to achieve tactical, strategic, and political goals" (2006, 22). This definition describes the basic function of airpower and its purpose as a means producing military might. A state's level of military airpower - the degree to which it can use military aircraft to achieve these goals - is based on the state's collection of fixed-winged[8] combat capable aircraft and the personnel, facilities, organizational structure, and command systems used to operate and employ these aircraft on the battlefield. Like most military innovations airpower contains both a hardware and software component (Eliason and Goldman 2003). The hardware refers to the physical equipment involved in aerial combat operations. This includes the aircraft itself, the facilities from which it operates, and the ordnance used to attack targets. The material and machinery serve as the physical incarnation of airpower - without them there is no combat power to speak of. The software element is more amorphous. It refers to the organizational support structure tasked with operating and maintaining the aircraft. This includes the pilots, ground crew, planning staff, and other personnel necessary to plan and undertake aerial missions. All these elements lie within a hierarchical institutional structure that reports to the national military leadership.

During the twentieth century the hardware component of airpower underwent a profound transformation. In the first years of powered flight, aviation materials, weapons, and technology were primitive in nature. The first Wright aircraft consisted largely of canvas sheets laid over a thin frame of white spruce held together by a rickety web of steel bracing wire.[9] As metallurgy improved and aeronautic science progressed, the wood and canvas frame gave way to lightweight alloy sheet metal. Post-WWII the alloy frames became sleeker and more aerodynamic by incorporating swept and delta

[8] The justification for excluding of rotary-wing aircraft and dirigibles from this definition is provided later in this chapter.
[9] This description of the material comes from the Wright's correspondence with US Army Lieutenant Thomas Selfridge in January 1908. See Wright Brothers, *Wright Letter to Lieut. Selfridge* (18 January 1908). Accessible at Library of Congress online archive: http://memory.loc.gov/master/mss/mwright/04/04005/0001d.jpg

wing configurations designed to facilitate the increase in speed associated with jet propulsion. In the latter half of the century radical design elements and sophisticated electronic systems were introduced as a means of avoiding enemy radar detection and improving targeting. Today, airpower is in the process of being revolutionized again, this time by advances in robotics and autonomous operation (Lambeth 2000).

The qualitative improvements in aircraft capabilities drastically altered the role, standing, and purpose of airpower. Through the pre-WWI period, aircraft were severely limited in payload, range, speed, and were often dangerous to operate even under ideal conditions. The war brought with it a substantial improvement in all aspects of aircraft design including the differentiation of aircraft by type and role (fighter, attack, bomber, reconnaissance, transport, etc.). Wartime experience showed that aircraft were useful in harassing enemy forces and impeding enemy troop movements but were hardly a decisive factor in determining battlefield outcomes (Kennett 1991). Aviation forces, though valuable for the protection of friendly forces and reconnaissance purposes, were viewed as a supplement to land and naval forces.

The technological developments brought on by the Great War set the stage for the Golden Age of Flight in the inter-war era. This twenty year period, marked as it was by the absence of major power war and the Great Depression, saw the most rapid and sustained era of improvement in aviation history. A succession of technical advances like the introduction of monocoque metal construction, cantilever wing design, retractable landing gear, fully enclosed cockpits, and the NACA engine cowling vastly improved aircraft speed, range, safety, and comfort. More important than the aerodynamic enhancements were innovations in aircraft engine performance and reliability. Wartime experience soured the aviation on community on the rotary engine[10] and instead gave rise to water-cooled in-line and air-cooled radial engines. The in-line and radial engines, with improved cylinder designs, proved far more efficient and effective for aviation purposes, especially when paired with newer high octane fuels. This later innovation proved crucial in developing the high output engines used in WWII-era fighter and attack aircraft. Experiments conducted during the war found, for instance, that shifting from 87 to 100 octane fuel improved the horsepower output of the Rolls-Royce Merlin II engine by over 40% (Meilinger 2003, 97).

The extraordinary advances in aviation in the inter-war period produced aircraft capable of determining the fate not of individual battles but of entire conflicts. From 1939-1945 hundreds of thousands of aircraft rolled off the assembly lines of the belligerent forces serving in every theater, performing every role imaginable. It was during WWII that airpower appeared to have attained parity with land and sea power. The nuclear revolution that followed allowed airpower (missile technology included) to decisively eclipse both land and sea power as the primary means of creating strategic military power. While land and sea forces remained crucial to national defense in conventional warfare, it was clear that a state's maximum potential destructive force in the form of nuclear weapons could only be delivered from the air (Brodie 1959).

The growth in the combat capabilities of the aircraft themselves could not have been realized without the congruent evolution of the weapons they carried. The first attempts at arming aircraft came in the form of entrepreneurial aviators taking their sidearms aloft in an effort to scare off opposing pilots. Experiments with rifles, machine

[10] The rotary engine was one in which the entire engine assembly rotated with the propeller. Though popular in the pre-WWI period this engine type produced enormous torque on the control stick and consumed disproportionately high levels of oil (which was often deposited on the pilot's windscreen).

guns, and grenades soon followed (Gross 2002). Most of these early pre-war steps were primitive in nature and provided little in the way of useable combat power. The first substantial steps forward came during the war years when fixed, forward-firing machines guns[11] were added to pursuit aircraft and large, destructive purpose-built bombs were added to the arsenals of the belligerents. The former provided a means of directly attacking enemy aircraft and light ground targets near the front. The latter, usually carried by large, multi-engine bombers, allowed commanders to reap destruction deep in enemy territory. The bombing of cities, carried out most vigorously by German dirigibles in WWI, was disconcerting to the public though, in reality, often resulted in only minor damage (Fredette 1976).

At the start of WWII the aerial weaponry available to the belligerents was similar to that which had been used in WWI. The primary difference, at least initially, was in the size and destructiveness of newer types of ordinance. Machine gun ammunition grew from 30 caliber, to 50 caliber, to 20mm, up to 75mm (Eden 2004). Bombs grew in size from 100lbs, to 500lbs, to 2000lbs up to over 4,000lbs. Both types of ordinance included newer, more powerful explosive compounds and deadlier incendiary materials like napalm and white phosphorous. Unguided rockets were also brought into action on a large scale for the first time. Though their accuracy was questionable, a full salvo of rockets from a single engine fighter could deliver the same destructive force as a full destroyer broadside (Boyne 2007). Thus, the contribution of aerial weaponry early in WWII was largely a matter of quantitative superiority over any particular qualitative

[11] Aircraft designer Anthony Focker's interrupter gear was the key innovation here. The interrupter gear allowed the machine gun to fire forward through the aircraft propeller. Up to that point aerial machine guns had been mounted either in a rearward facing observation station or on the upper wing well above the pilot. In the latter case, an empty or malfunctioning weapon (not an uncommon occurrence) could only be accessed by the pilot taking his hands off the controls and standing upright in the cockpit. See Brodie and Brodie 1973, 178.

measure. Simply put, aerial attack had grown more deadly because there were more aircraft attacking with larger payloads.[12]

Eventually wartime pressures would lead to the introduction of two distinct types of ordnance that would alter the nature of aerial warfare. The first was, of course, the atomic bomb. The result of a massive American scientific and engineering effort, the Manhattan Project produced the elusive “war-winning” weapon in the form the Little Boy and Fat Man bombs dropped over Hiroshima and Nagasaki in August 1945. The arrival of nuclear weapons instantly afforded air forces status over the other services by providing the air arm a means of desolating miles of enemy territory in a matter of seconds. The “absolute weapon” changed the nature of international relations (Brodie et al. 1946). By severing the link between victory and survival, nuclear weapons imposed an uneasy peace between the United States and U.S.S.R. based on mutually assured destruction (Van Creveld 2011). Thus, owing to an innovation in weaponry rather than the aircraft themselves, the power and destructiveness of aerial attack grew to near limitless proportion.

The second major ordinance innovation was the development of precision guided munitions. One of the first was the German designed *Fritz X* wire guided glide bomb used to attack Allied shipping in the Mediterranean. The 3,000lb stub winged explosive was guided to its target via a control stick operated by an observer located in the nose of the launching aircraft (Bogart 1976). Though its direct contribution to the war effort was limited, the *Fritz X* marked the beginning of a long evolutionary process of enhancing aerial attack capabilities not through greater explosive power but through the accurate delivery of small to moderate payloads. The true value of precision was only realized a

[12] Major improvements in aerial doctrine, operational planning, and tactics were also important as well and are addressed in the next section.

half century later when the United States showcased the crippling effects of air launched precision guided munitions during the 1991 Persian Gulf War (Hallion 1997). Deemed something of a "Revolution in Military Affairs" (see Adamsky 2010), the arrival of laser, wire, and GPS guided ordinance heralded another qualitative leap forward in airpower capability.

Throughout the 20th century the software component of airpower evolved in line with the technological advances. In order for this to occur, military leaders had to move away from their vision of airpower as a "sustaining innovation", i.e. one that would improve existing practices. Instead, airpower needed to be recognized for what it was, a "disruptive innovation", i.e. one that would profoundly affected prior business practices and, in so doing, require the establishment of new organizational norms and structures to be used effectively (Horowitz 2010). This resulted in the creation of dedicated military aviation components within the existing dual service (Army and Navy) systems of the United States and the European powers. For example, the British government established the Royal Flying Corps (RFC) in 1912 as a means of consolidating early aviation assets within the Army. The RFC then commanded British aerial military forces during WWI under the guidance of Army leadership. Immediately after the war's conclusion, however, the Royal Flying Corps and the Royal Naval Air Service were merged to create the first independent aerial service – the Royal Air Force (Omissi 1990). Eventually, most military air units followed a similar path by breaking off to form their own independent services on par with land and sea services.

Beyond the organizational structure there was also the matter of developing airpower doctrine, strategy, and tactics. In the pre-WWI era relatively little thought was given to the methods by which aircraft could be used against an adversary. Wartime exigencies led France, Germany, Italy and the other belligerents to produce a variety of battlefield tactics over the skies of Europe (Kennett 1991, 63-71). In the interwar period, airpower doctrine became increasingly sophisticated. Airpower theorists like Gulio Duhet, Hugh Trenchard, and Billy Mitchell developed complex strategies for airpower employment. These theories were complimented by practical experiences gained in WWII (Meilinger 1997).

The inter-war era saw the first sustained period in which national military aviation doctrine began to fundamentally diverge among the major powers. This divergence in aerial attack strategies and tactics influenced aircraft design, production, and organization in the mid to late 1930s. For instance, in the United States and Britain, belief in the efficacy of large-scale strategic bombing led to the production of large bomber fleets designed to deliver precision strikes on enemy industrial targets. Defense resources were allocated in accordance with this belief. As a result, the United States would enter the war with a series of high-quality bomber aircraft like the B-17 and B-25 but with a dearth of capable front-line fighter aircraft (Murray 1996). Contrast this with the German aviation high command and its emphasis on operational-level combat support. The importance of battlefield interdiction and close air support missions in German aviation doctrine resulted in technical and tactical innovations specific to these areas. As such, German strategic bombing and naval aviation capabilities suffered (Muller 1996). Post-WWII, the superpowers continued to generate new aerial targeting strategies, this time under the aegis of nuclear warfare. The principal strategy of the period by both superpowers included the use of large bomber forces as a means of deterring enemy aggression by threatening retaliation via an attack on the enemy states' military forces (counter force) and civilian populations (counter value) (Brodie 1959; Friedberg 1980).

Later in the 20th century, after the U.S. experience in Vietnam and the Israeli experiences in 1968 and 1973, the importance of tactical fighter and attack aircraft returned to prominence. This coincided with the rediscovery of joint air, land, and naval warfare and a renewed interest in advanced aerial combat training. The establishment of sophisticated air combat instruction programs in the United States soon expanded internationally, with dozens of allied air forces taking part in American training exercises or developing similar exercises of their own (Boyne 2000). The efficacy of new personnel training and preparation techniques was put on display in Operation Desert Storm. The swift and overwhelming coalition victory marked a high point for military airpower (Cohen 1994).

Finally, it is important to acknowledge the limitation of my airpower definition to fixed-wing aviation only. The decision to exclude both dirigibles and rotary-wing aircraft was made for two reasons. First, there is the issue of comparability of units over time. A primary goal of this study is to assess trends in airpower diffusion over several decades spanning from military aviation emergence to the present day. Over this time period fixed-wing aircraft have been a constant whereas both dirigibles and rotary-wing aircraft are limited to only a single era. During the early airpower period lighter-than-air craft rivaled fixed-wing aircraft for aviation-related funding and were seen as a realistic alternative to airplanes in the reconnaissance and ground attack role. But as technology progressed even the most advanced dirigibles began to show their vulnerabilities, so much so that by war's end the vaunted German Zeppelin had been pulled from front-line duty on the Western Front.[13] The dirigible would quickly fade from military service and,

[13] By early 1917 even the Zeppelin's famed inventor and namesake Count Ferdinand Von Zeppelin had come to accept the technological inferiority of his most prized achievement. Visiting General Von Hindenburg shortly before his death, Zeppelin stated unequivocally that "he regarded his airships as an antiquated weapon in warfare. In his judgment, the airplane and not the airship will, in the future, dominate the sky" (Norman 1968, 412).

as a result, have little impact on airpower capabilities in the late 20th century. By contrast, rotary-wing aircraft, i.e. helicopters, have had a deep and lasting impact on military airpower diffusion but one that, due to its relatively recent invention, was not fully appreciated until the latter half of the century. This means, of course, that there is no early reference point from which to compare rotary-wing aviation diffusion patterns over time. Simply stated, the helicopter was not in existence in the early airpower diffusion period and therefore it is impossible to compare its diffusion rate and intensity across the early and late airpower adoption eras.

Second, beyond temporal comparability there is also the issue of mission and purpose. While the dirigible and, to an even greater extent, the helicopter are (or were) flexible, multi-mission weapon systems neither innovation can provide the full breadth of capabilities offered by the variety of fixed-wing aircraft in service today. Where the dirigible originally offered great promise in reconnaissance and strategic bombing the airplane quickly eclipsed these capabilities. Where the helicopter is useful for close air support, with proper service support[14] the airplane can fulfill this role while also providing air superiority, battlefield interdiction, strategic bombing, and other important aviation missions. Only in the tactical transportation role does the helicopter truly surpass the fixed-aircraft in capability.

This is not to say that rotary-wing aircraft are not useful, highly effective weapon systems. Far from it. Rather, I argue that helicopters and fixed-wing aircraft serve different functions, perform different mission-sets, and are therefore unlike units deserving of their own separate methods of analysis and study. The two weapon systems are not directly substitutable and, as a result, must be viewed as separate cases of

[14] A key caveat given the history of American inter-service disputes over this very issue (See Bergeson 1980).

innovation diffusion. While this dissertation focuses solely on fixed-wing aviation, future innovation diffusion researchers may find it useful to apply the methods used here to the case of rotary-wing aviation in late 20th and early 21st centuries.

III. Operationalizing Airpower

In this study airpower diffusion, or more specifically airpower adoption, is measured in two ways. The first is time to adoption. This is, simply, the amount of time that elapsed between innovation emergence (1909) and national-level airpower adoption. The point of airpower adoption is defined as the year in which a state established its first permanent, fixed-wing military aviation unit.[15] The time to adoption approach is applied to the early airpower adopter cohort, namely those states in existence at innovation emergence. The focus on the aviation unit, an organizational component, highlights the software side of the airpower definition. In this case, the time to adoption is viewed as a measure of a state's willingness to experiment with military aviation at a time when aeronautic technology was in its infancy.

The second measure of airpower diffusion is adoption intensity. This method focuses on the hardware aspect of airpower, specifically aircraft acquisitions and inventories. The adoption intensity approach is applied to the major powers in the early airpower adopter cohort[16] and to all states in the late airpower adopter cohort.[17] The measure serves as an indicator of a state's commitment to airpower as a means of warfare. Also, in analyzing the late airpower adopter cohort, aircraft counts are broken down further by aircraft generations that are then weighted. Aircraft belonging to newer generations are

[15] The rationale for selecting this particular indicator is discussed further in Chapter 4.
[16] The limitation to only the major powers in the early airpower adopter cohort is due to the unavailability of reliable aircraft inventory records for smaller powers in the early 20th century.
[17] Note that the time to adoption approach is not applied to the late airpower adopter cohort for two reasons: (1) lack of variation on the dependent variable and (2) poor data quality. This is discussed further in Chapter 5.

assigned progressively higher point values. The total points are then aggregated for each state to create an airpower score.[18] The airpower score then serves as a measure of a state's overall airpower capabilities. The analysis in Chapter 5 uses both total aircraft counts and airpower scores as measures of airpower adoption intensity.

IV. Findings

Ultimately, I find there are two key determinants of airpower adoption. The first is resource availability. Simply put, those states with the national military resources available to purchase and support combat aircraft usually do. The second is status. In the early 20th century, when aviation technology was in its infancy, states often pursued aircraft not for their practical utility (which was minimal) but rather for the aura of modernity and illusion of capability the aircraft itself provided to its possessor. In the late 20th century, the status value of military aircraft disappeared. Instead, those states most connected to the international system, and therefore most concerned with relative status among their peers, became less reliant on airpower. Additionally, I find that external threats encourage airpower adoption, domestic pro-aviation advocacy groups were key drivers of initial aircraft acquisitions, and that diplomatic channels facilitate the flow of aviation technology and the intensity of adoption. Interestingly, I also find that overall global airpower capabilities, as measured by the number and quality of combat aircraft in service, peaked at the end of the Cold War but have, on a per state basis, been in steady decline since the late 1960s.

[18] The weighting of aircraft by generations is due to the progressively widening capability gap between the weakest and strongest combat aircraft. In the early 20th century, particularly pre-WWI, the performance difference between military aircraft models was negligible. In the early 21th century variance in combat aircraft capabilities can be massive. It is difficult, for instance, to equate a propeller driven armed trainer like the T-6 Texan with a supersonic stealth fighter like the F-22.

V. Organizing the Study

The following chapter provides a review of the literature on military innovation diffusion and identifies a series of competing hypotheses on the determinants of airpower diffusion specifically. The three subsequent chapters present the empirical evidence used to test these hypotheses. Each chapter focuses on a distinct sample of the wider population of states to assess the relative strength of each explanatory variable under varying circumstances. The final chapter aggregates the findings into two proposed models of military airpower adoption. These models are intended to serve as a resource to guide future research into military innovation diffusion. The dissertation concludes by offering several suggestions for future research.

Chapter 2: The Theory of Military Airpower Diffusion

The purpose of this chapter is to review the literature on the diffusion of military innovations. The chapter is split into three sections. The first section reviews existing military innovation diffusion theory and identifies a set of competing hypotheses explaining the proliferation of military airpower in the early and late 20th century. The second section focuses on innovation emergence and presents a set of inter-related hypotheses regarding the adoption of military aviation in the pre-WWI era. The final section discusses additional explanations that were rejected on theoretical and methodological grounds.

I. Theorizing Military Innovation Adoption

In order to understand why states adopt military innovations, it is helpful to begin with an important empirical observation: in general, military organizations around the world are remarkably similar in institutional design. For one, nearly every state has a military. Of these, nearly all are separated into three (or more) distinct, co-equal branches based upon the domain in which their weapons operate.[19] Within these services the basic classification of units – infantry, artillery, tanks, aircraft, etc. – are common across the international community. What variance does exist largely comes from within these system categories. Whereas one state may have weapons of WWII vintage, another may be equipped with the sophisticated technology of 21st century warfare. Nevertheless, the core elements, both weapons and organizational structures, are shared by nearly all members of the system. There is, then, a broad convergence of military means, methods,

[19] The standard tri-service arrangement includes land forces under the Army, sea forces under the Navy, and air forces under the Air Force.

basic doctrine, and organization internationally around a somewhat vaguely-specified ideal-type.[20]

A. Security/Threats

Realists argue that military convergence is driven by the competitive nature of the international environment. In the anarchic international system each state will seek out the weapons and equipment that maximize one's military capabilities. States that are able to do so are likely to survive. Those that fail to do so are lost to history. Over time, through this process of elimination, the most effective systems are identified and gradually adopted as the standard for military organizations (Waltz 1979). The elimination of states that are unable, or unwilling, to adopt superior technologies then results in military convergence. Indeed, as Waltz notes, international "competition produces a tendency towards sameness" among the states in the system (Waltz 1979, 127).

The argument for convergence presents a somewhat simplistic, easily testable proposition regarding the diffusion of military airpower. One would expect that all states in the international system would maintain a bare minimum of aviation capabilities. This is not to say that airpower capabilities would be distributed equally. All states must make defense trade-offs between different types of military capabilities. Indeed, as Allison and Morris maintain, weapons acquisition decisions are inevitably bound by the "constraints of technology and budget" (1975, 103). Still, one would expect that isomorphic pressures

[20] This ideal-type is just that; many advanced militaries differ from this ideal-type in some way, shape, or form. The United States Marine Corps, with its emphasis on amphibious warfare and joint land, sea, and air capabilities, is rather unusual among Western militaries. Similarly, the French Gendarmes, a hybrid domestic military and law-enforcement institution, is a uniquely French invention largely confined to Francophone West Africa.

would ultimately encourage even weaker states to acquire airpower capabilities in some capacity to maintain their competitiveness. This leads to the following hypothesis:

H_1: *Military airpower will diffuse to all states in the international system*

The realist explanation for military isomorphism is easily understood given its comparability to the natural selection process in the biological world. States, like animals, simply emulate those military permutations that increase their odds of survival. But unlike animals, state mutations are not naturally endowed but rather artificially created by political institutions through the policy decision making process. Making these decisions, particularly the decisions on how best to organize one's military, requires a great deal of information. This information is often difficult to ascertain as there may be an incentive on the part of other states to distort the results of a particular conflict or the performance of a particular weapons system.[21]

In this environment of imperfect information, the evaluation of potential military innovations must take into account the types of threats states expect to encounter. This is in keeping with the realist contention that states, acting as unitary, rational actors, strategically assess their most likely potential adversaries and develop the appropriate military capabilities to counter them. In so doing, a primary consideration is proximity. Simply put, foreign enemies that are nearby are more dangerous than those that are far away. The reasons for this are rather straightforward. For one, proximate states interact more frequently with one another and thus there are more opportunities for disputes to emerge. Secondly, foreign invasion can be accomplished quicker and easier over shorter distances. Ken Boulding's Loss of Strength gradient shows, for instance, that the ability of a state to project power declines precipitously with distance (1962). Consequently, the

[21] The possible reasons for distorting the effectiveness of a particular weapons system are myriad. A state may not wish to reveal its strengths, it may wish to conceal its weaknesses, it may wish to sell said weapon, etc.

threat posed by powerful but distant states is often far less than that posed by weak but proximate states.

Proximity being key in determining external threats, and external threats being key to determining military force structures, we can expect that regionally proximate states arrange their military forces in order to defend themselves against one another. This is, of course, how arms races occur (Jervis 1978). When one state introduces a military innovation it upsets the existing regional balance of power.[22] This new capability degrades the relative capability of potential enemy states who then respond by acquiring the innovation themselves or by 'counter-innovating' i.e. developing a separate, distinct innovation that mitigates the advantage of the original innovation (Elman 1999). The initial innovation adoption serves as a forcing function with the first adoption prompting additional adoptions. This is born out empirically. Resende-Santos finds, for instance, that the diffusion of Prussian military tactics and training across Latin America can be traced to the Chilean military's initial decision to employ European methods of warfare in the early 1880's (2007). Chile's initial adoption in 1890 had a domino effect. The Chilean adoption prompted Argentina to adopt. Argentinian interest led Paraguay, Uruguay, and eventually Brazil to follow suit (Johnson 1964, 70). Thus, the proximity of South American states encouraged emulation resulting in the regional diffusion of German military methods. Similarly, then, we should expect that military airpower diffusion should take on a distinctly regional pattern. This leads to the following hypothesis:

> *H_2: Military airpower will diffuse more readily among states within the same geographic region*

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[22] It is important to note that regional innovation diffusion starts with an initial adoption. Only after a first-mover acquires a particular weapon, tactic, or strategy do neighboring states begin to perceive their relative inferiority and thus their need to acquire said innovation.

While proximity is key to determining potential threats, the intensity of those threats is largely dependent on historical relations between states. Some states have, either through geographic fortune, diplomatic skill, or just plain luck, been able to maintain peaceful relations with their neighbors. Many, though, have a long legacy of conflict and animosity with other members of the international system. This variation in historical experience, and relative peacefulness, results in varying levels of external threat. States that have experienced high levels of conflict are more insecure and therefore have an incentive to acquire military innovations, including aircraft. More peaceful states do not feel the same pressure.

The notion that states arm because they have a history of violence is rather intuitive. The difficulty comes in defining what, exactly, a history of violence looks like and how it can be measured. In this case, I rely on two measures to capture the intensity of external threats: (1) militarized interstate disputes (MIDs) and (2) enduring rivalries. Militarized interstate disputes are "historical cases of conflict in which the threat, display or use of military force short of war by one member state is explicitly directed towards the government, official representatives, official forces, property, or territory of another state" (Jones et al. 1996, 163). These incidents serve as an indication of a state's relative peacefulness. The greater the frequency of MIDs the more threatened a state feels and thus the more likely it is to pursue airpower. This leads to the following hypothesis:

H_3: States that have a history of conflict (i.e. high number of militarized interstate disputes) will be more likely to pursue military airpower

The second measure of external threat is enduring rivalries. States with a history of MIDs may feel generally insecure, but if those threats are spread out across several other states the intensity of threat may be relatively low. However, if a state has a troubling relationship with a particular enemy, one that has endured over time, this can represent a very intense threat, one the state must prepare to defend against. More specifically, if a state has engaged in it least three MIDs with the same opponent within the last 15 years it is said to be involved in an enduring rivalry (Diehl 1985; Diehl and Goertz 1992). Since enduring rivalries inflate threats and threats inflate the desire to acquire weapons, we would expect that states engaged in enduring rivalries would be more likely to pursue airpower. This leads to the following hypothesis:

H_4: States engaged in enduring rivalries will be more likely to pursue military airpower

B. Resources

While security concerns may drive military innovation diffusion, national level decisions on weapons acquisitions are inevitably shaped by resource constraints. In his work on the diffusion of military power, Michael Horowitz finds that financial intensity is a key factor in determining the speed and extent to which military innovations spread across the international system (2010). Financial intensity refers to the particular resource mobilization requirements necessary to adopt an innovation. Innovations with relatively low per-unit costs are the least financially intensive and therefore most likely to diffuse (Horowitz 2010, 31). Similarly, dual purposes innovations, those that can be used for both military and civilian applications, are less financially intense and therefore more likely to diffuse. Dual purpose innovations are not necessarily less expensive dollar-wise in the short term but offer a greater chance at recouping the state's investment in a particular technology.

Now, Horowitz's study is designed to identify innovation characteristics that influence the relative speed and ubiquity of innovation distribution. The unit of analysis is the innovation itself. By contrast, this study focuses on national level characteristics as determinants of airpower adoption patterns. The emphasis is on identifying state attributes that indicate high or low airpower interest. The unit of analysis is the state rather than the innovation. Horowitz's work does not explain, for instance, how variation in national characteristics shape the intensity of innovation adoption nor does it capture changes in diffusion mechanisms over time. Even so, Horowitz's insight on financial intensity is useful in that it explicitly acknowledges the importance of resources, specifically the notion that expensive innovations are least likely to diffuse.

Nowhere could this be more applicable than in the case of airpower. Airpower is by all measures an expensive form of military power that requires a massive investment in technologically advanced machinery. Today, the U.S.-produced F-16, one of the most successfully exported fighters in the world and one considered relatively inexpensive, costs nearly $19 million per aircraft.[23] This represents only the initial purchase price. When the costs associated with support facilities, aircraft maintenance, personnel, fuel, and munitions are included the total price tag rises precipitously. The Center for Defense Information estimates, for instance, that in 2010 the operating costs of a single F-16D was around $23,000 per flight hour (Wheeler 2011). In the U.S. military, standard fighter and attack aircraft are flown anywhere between 200 and 350 hours a year depending on deployment.[24] This results in a consistent annual investment of $4.6 to $8 million a year for the life of the aircraft.

The high costs of military aviation are not, however, a modern phenomenon. While the complexity and sophistication of modern aircraft have produced some extremely costly examples[25], the heavy resource requirements for military aircraft have been

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[23] Price as quoted for F-16 C/D Block on U.S. Air Force website: http://www.af.mil/information/factsheets/factsheet.asp?id=103
[24] Mareshah Haynes, "Pilot Reaches 1,000 Combat Hours Flown," *Air Force Print News Today* (28 February 2008). Accessible at: http://www.1af.acc.af.mil/news/story_print.asp?id=123088143
[25] See, for instance, the $2 billion per plane price tag for the U.S. Air Force's B-2 Spirit. Tony Capaccio, "U.S. Bomber Planes at $81 Billion Seen 47% More Than Plan," *Bloomberg* (6

around since the very beginning. For instance, when the Wright brothers sold the first aircraft to the U.S. Army in 1909 they did so for $25,000 (Budiansky 2004, 31). Some five years later during the Great War, mass manufacturing techniques brought down individual aircraft costs considerably. For example, a British SE5a fighter, a model typical of the mid-war period, could be produced for around $4,000. Added to this price, however, was the cost of training a pilot which ran about $25,000 (Budiansky 2004, 78). To put this in perspective, the U.S. War Department estimated that in 1918 the per-unit cost of a standard infantry weapon like the British-designed Lee Enfield rifle was about $26 dollars. Similarly, the cost of a 75mm artillery shell, the most common model in use in the French Army at the time, was around $11 dollars per-unit (U.S. War Department 1918, 125 and 184). By this calculation a single operational SE5a fighter cost roughly the same as 1,115 Enfield rifles or 2,636 75mm artillery shells.

Now originally I thought to test the influence of resources on airpower diffusion patterns by using national levels of military expenditures. Unfortunately, this method presented endogeneity issues. While states that spend a lot on their militaries generally have more resources to spend on aircraft, it also the case that the more aircraft a state acquires the greater its operations and maintenances costs. Greater operations and maintenance costs then naturally lead to greater resource requirements in order to sustain military capabilities over time. This then puts upward pressure on defense spending. Ultimately it is unclear the degree to which defense spending spurs aircraft acquisitions or if the follow-on costs associated with aircraft maintenance and operations boost military expenditures.

December 2013). Accessible at: http://www.bloomberg.com/news/2013-12-06/u-s-bombers-seen-costing-81-billion-47-more-than-plan.html

In order to avoid this causal loop I decided to use an alternative measure of state resources and national power. Specifically, I use the Composite Index of National Capability (CINC) score developed as part of the Correlates of War project. The CINC score provides a single numerical value that is computed by summing all observations on each of the 6 national military capability components for a given year[26], converting each state's absolute component to a share of the international system, and then averaging across the 6 components. This score is a more accurate measure of state resources that avoids some of the issues encountered in using military spending alone. This leads to the following hypothesis:

H_5: States with high national power resources (as measured by Composite Index of National Capability (CINC) scores) will be more likely to pursue military airpower

In addition to national power resources, military and political leaders must also take into account the demographic characteristics of their societies when shaping military force structures. States with large populations are capable of fielding large armies. Sparsely populated states are not. Low population states are at a disadvantage in their attempts to project military power relative to their highly populated neighbors. Airpower, with its low personnel requirements relative to its destructive capacity, offers an alternative means for smaller states to generate military power. Of course, this comes with a cost. As mentioned above, the resources required to recruit and equip infantry pale in comparison to the resources needed to both acquire and operate military aircraft. Lacking adequate demographic endowment, small states can substitute capital (aircraft) for labor (soldiers) in order to enhance their military capabilities.[27] Heavily populated

[26] The 6 national military capability components are: iron and steel production, military expenditures, military personnel, primary energy consumption, total population, and urban population.
[27] This assumes, of course, that small states have the minimal level of resources necessary to acquire airpower assets. This may be an issue for micro-states with very small or non-existent

states have the luxury of doing the opposite. Israel provides an obvious example. Saddled with a tiny population relative to its neighbors, the Israeli government took a deliberate decision to invest in military methods and weaponry to maximize combat power while putting personnel at minimal risk. The IAF has been the chief benefactor of this policy (Brun 2011). The rapid adoption and expansion of airpower capabilities in Israel was, and continues to be, a direct result of population constraints. This leads to the following hypothesis:

H_6: States with small populations will be more likely to pursue military airpower

Recall that realists posit two methods for increasing a state's relative power: internal balancing and external balancing. The former refers to the production of military might via domestic research and development processes. The latter refers to the diplomatic maneuvering political leaders undertake to acquire allies against potential enemies. The acquisition of allies and the alienation of enemies says little about how military innovations are produced. It can, however, affect the diffusion of military innovations among alliance partners.

Sharing military innovations with one's allies has several tangible benefits. The most obvious benefit comes from enhancing the immediate military capabilities of the allied state. Enhancing the military capabilities of an ally naturally enhances the combined capabilities of the alliance as a whole. This improves the overall security of both states but also transfers, to some extent, a greater share of the security burden from the innovating state to the receiving state. Second, technology sharing strengthens the bond between allies by establishing regularized patterns of military exchange. Sharing technology builds trust which improves diplomatic relations and, ideally, strengthens the

military forces. For the purposes of this study states without military forces or with populations under 500,000 are omitted from the analysis. This eliminates those states incapable of any form of military substitution.

bonds of the alliance. For example, Anglo-American technology sharing in WWII enhanced the overall strength of the alliance while cementing the ties between the United States and Great Britain. In the post-Cold War period this technological cooperation continues. American willingness to allow the British military full technical access to the sensitive systems in its newest fighter aircraft the F-35 is but the latest example.[28]

In addition to adding capabilities, technology transfer also increases the interoperability of military forces among allied states. Greater interoperability enhances the overall military effectiveness of the allied military forces by allowing both parties to pool common weapons and equipment. This mitigates the logistical issues involved in supporting vehicles and systems of various types on the battlefield. It also eases the degree to which an ally can be resupplied. For instance, the Israeli move away from French aircraft and towards American models in the early 1970's came in response to American military aid in the 1973 Yom Kippur War. Israeli leadership recognized that incorporating American weapons and equipment in future conflict would be easier if fielded Israeli forces were already trained and equipped with American arms (Norton 2004).

Lastly, the transfer of innovative methods and machines has the potential to improve an ally's long term productivity and innovative capacity. Providing sophisticated technology and technical assistance can improve the defense industrial capabilities of the receiving state. The innovation receiver then becomes an innovation producer, one that transfers this new knowledge or technology back to the originating state. American military aid to Israel in the mid-twentieth century had just this effect. Early U.S.

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[28] Jonathon Beale, "UK Receives First F-35 Stealth Fighter Jet from US," *BBC News* (19 July 2012). Accessible at: http://www.bbc.com/news/uk-18919388

technical assistance facilitated the development of an advanced Israeli aerospace industry, particularly in the area of radar design, avionics, and robotics. Once established, Israeli defense manufacturers began developing their own innovations which were incorporated into American weapons systems. The jointly developed "Iron Dome" anti-missile system is a prime example.[29]

In short, states are incentivized to arm both themselves and their allies. Doing so increases the capabilities of the alliance, promotes trust, improves logistical cooperation, and may over time lead to reciprocal innovation sharing. One would expect, then, that innovations like military airpower would diffuse quicker and more completely from leading airpower states[30] to their less powerful allies. This results in the following hypothesis:

H_7: States allied with leading airpower states are more likely to adopt airpower themselves

C. Regime Type

The type of political system in which political and military leaders operate has the potential to influence the types of weapons they procure and the types of military structures that result. In authoritarian regimes political leaders can make military structuring decisions without regard to the negative effect they may have on their own citizens. The effect of weapons on enemy forces is of prime importance; little concern is given for how said weapon will affect one's own soldiers or the society that pays for them.

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[29] Cristina Silva and Seth Robson, "Technology Enabling US to Build Improved Missile Defense Systems," *Stars and Stripes* (14 December 2012). Accessible at: http://www.stripes.com/news/technology-enabling-us-to-build-improved-missile-defense-systems-1.200676

[30] For clarity, the two leading airpower states in the earlier aviation period were France and Germany while in the late airpower period the United States and the Soviet Union dominated the global military aviation scene. This is discussed more thoroughly in the following chapters.

Often the sacrificing of personnel in pursuit of battlefield outcomes is taken for granted. For example, during the Iran-Iraq war, Iranian military commanders used Basij militias composed of young ideological volunteers to clear enemy mines and defensive structures. The untrained but highly motivated recruits lined up arm in arm to march through minefields clearing the way for army troops behind them. As one could imagine, the effects were devastating (Moin 2000).

Democratic leaders do not have the luxury of sustaining high casualties without fearing for their own electoral futures. This sensitivity to personnel losses has been demonstrated empirically. Valentino et al. find, for instance, that democracies use a variety of techniques to minimize the human costs of war (2010). Specifically, democratic states seek to mitigate costs by generating high military capabilities, joining powerful coalitions, fighting wars in non-contiguous territories to their home territories, and by using battlefield military strategies that minimize domestic fatalities. Airpower represents one such strategy. The destructive force of aerial delivered ordinance is several times that of an infantry platoon and can be accomplished by putting only a single pilot at risk.[31] For leaders in powerful democratic states like the U.S., Britain, and France, airpower provides an opportunity to "do something" in foreign crises without putting large numbers of soldiers at risk.

Nowhere was the democratic aversion to casualties more evident than in WWII. Both Franklin Roosevelt and, to an even greater extent, Winston Churchill, agonized over personnel losses even in victory. In the Atlantic, Churchill's policy of containment and reluctance to concede to cross-channel invasion plans until 1944 arose of an effort to

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[31] Here I am referring to the human costs to one's own people. The human costs imposed upon the enemy, civilians included, may be considered in the initial phases of conflict but in a long, drawn out affair desperation sets in and the selectivity of military force wanes in favor of overwhelming (and often indiscriminate) firepower (Downes 2006).

sustain public support for the war by minimizing British battle deaths (Hastings 2011). Likewise, Harry Truman's willingness to drop the atomic bomb came out of a desire to avoid the estimated one million American casualties that would come with an invasion of mainland Japan (Correll 2009). Contrast this with Stalin who, unencumbered by electoral constraints, could afford to throw away poorly equipped troops by the millions.

Drawing on Kantian principles of democratic pacifism, Gartzke posits that this casualty aversion manifests itself in a conscious decision on the part of the political leadership to substitute capital (i.e. military weapons/equipment) for labor (troops) (2001).[32] Just as lightly populated states can make up for a lack of personnel with capital, democracies can similarly hope to substitute equipment for personnel losses.[33] In this way they can structure their forces around technology and massive firepower in order to spare the lives of their soldiers. Again airpower is a prime candidate for substitution. Thus, we would expect that democratic states would be more likely to rely on airpower as a means of warfare. This leads to the following hypothesis:

H_8: Democratic states are more likely to pursue military airpower

D. Status

The notion that state behavior is a consequence of rational action is challenged by constructivism. For constructivist thinkers, state action is not the result of an objective calculation of optimal policy but rather a highly contextualized outcome derived from one's socially constructed vision of the world. The emphasis is less on the technological attributes of an innovation, and more on the role and meaning given to the innovation by

[32] Gartzke ultimately finds little evidence to support this claim. Nevertheless, the logic is sound.
[33] Once again it is important to acknowledge that a modicum of resources is required if such a tradeoff is to be made. The poorest democratic states, no matter how averse to casualties they may be, simply would not have the resources to rely on military aviation as a means of defending territory.

its creators. By contrast, rationalist theories assume that military innovations, specifically hardware innovations, have an obvious military application. Weapons of any sort, including combat aircraft, are simply tools of destruction. The "meaning" of an innovation is important only in the sense that its mere existence represents a threat to other states. Constructivism unpacks this concept. It asks if we can realistically assert that weapons in the possession of one state are as threatening as those of another. For example, Wendt asserts that "500 British nuclear weapons are less threatening to the United States than 5 North Korean nuclear weapons, because the British are friends of the United States and the North Koreans are not" (1995, 73). Though the distribution of capabilities (and innovations) may set the physical limitations of conflict, the capabilities themselves do not threaten. The governments that control them do.

A key element of constructivism is the emphasis on norms as a means of structuring the interaction of individuals, organizations, and states. A norm is "a standard of appropriate behavior for actors with a given identity" (Finnemore and Sikkink 1998, 891). These standards set expectations that an entity will act in a regularized, predictable manner in a given situation. They provide order in the absence of authority. This is particularly important in the international arena where no single authority exists. By creating or assuming identities states become more predictable in their behavior and, consequently, their actions and intentions become easier to understand and interpret.

So, what role do norms play in the military innovation diffusion process? For one, norms can guide military innovation processes down a particular development pathway. For example, Just War Theory (*jus in bello*) stipulates that violence in wartime should be directed only at enemy combatants (distinction) and, when force is used, should be limited only to that which is necessary to achieve one's military objectives (necessity) (Crawford 2003). These principles are enshrined in the treaties and protocols of the

Geneva Conventions. Adherence to the norms of distinction and military necessity encourages states to develop innovations that limit non-combatant casualties and unnecessary property damage. Research that might otherwise focus on weapons with maximum destructive capacity is instead directed towards systems with precision-guidance and minimal collateral damage. The U.S. GBU-39 Small Diameter Bomb was, for instance, designed for the express purpose of reducing civilian casualties.[34]

The broadly accepted norm against the production and use of weapons of mass destruction is another example. Since states are discouraged from engaging in chemical, biological, and nuclear warfare there is a natural tendency to shift resources to more practical, conventional warfare oriented innovations (See Tannenwald 1999). Likewise, the Treaty on Nuclear Non-Proliferation actually encourages non-nuclear states to pursue peaceful atomic research while expressly prohibiting the development of atomic weapons. Even within the area of conventional weapons normative constraints influence military innovation processes. Witness the International Campaign to Ban Land Mines. Price shows, for instance, how a transnational network of anti-mine advocates were able to pressure over 90 countries into eliminating land mines from their military arsenals (1998). Through a concerted effort of lobbying and persuasion, the ICBL was able to alter the collective understanding of what land mines are and how they should be used. The land mine moved from being a standard means of area denial to an unacceptably indiscriminate killing device (Price 1998).

Norms provide guidance to political leaders on how they should organize and conduct themselves in their relations with other states. This is important for newly established states. Unlike older governments, young states often have little experience in

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[34] David Hambling, "5 Weapons Systems to Reduce Collateral Damage," *Popular Mechanics* (2012). Accessed at: http://www.popularmechanics.com/technology/military/planes-uavs/5-weapons-systems-to-reduce-collateral-damage-gbu-39b-focused-lethality-munition#slide-2

political activities – namely defense and foreign policy decision making. Having relied in the past on another political entity, be it a colonial master or larger national government, to conduct the affairs of state, political leaders in new states need assistance in determining how best to structure domestic political institutions and establish international relationships. Norms provide guidance on how to construct these institutions. For example, the near universal acceptance of diplomatic protocol in the form of embassies and ambassadors provides a template for states to follow. In this case, the adoption of the norm of diplomatic exchange serves both a practical function (improving bilateral communication) and a ceremonial function (de facto recognition) (Hamilton and Langhorne 2010).

Organizations like the International Monetary Fund, the World Bank, and the United Nations facilitate norm diffusion by providing technical advice on governance and policy questions. This advice can influence not only policy but also the structural composition of state institutions. For example, Finnemore finds that in the 1960's and 70's newly independent states in Sub-Saharan Africa took cues from the United Nations Education, Scientific, and Cultural Organization (UNESCO) on the importance establishing state-administered science bureaucracies (1993). Though many of these states had little demand for scientific research, they came to adopt UNESCO's opinion that "science policy should be the responsibility of an organization at the highest level of government" (Finnemore 1993, 583). Political leaders in these relatively young, impressionable states came to understand science as a necessary measure of modernity. Thus, state institutional development was driven by the desire to comply with an established international norm.

Wendt and Barnett build upon this notion by exploring how the quest for political recognition and status among newly independent states encourages their political leaders to adopt the strategies and technologies of the major powers (1993). Adopting these elements is an important part of emerging state formation. European states were forged in a competitive international environment where external threats drove the internal structuring of state institutions. By contrast, emerging states are often threatened more by domestic insecurity and weak political institutions than external enemies. To counteract this insecurity political leaders seek legitimacy by adopting all the trappings of progressive Western states. This involves the adoption of Western-style capital-intensive military organizational structures and weapons technologies even when doing so hinders rather than improves military capabilities (Wendt and Barnett 1993).

Wendt and Barnett's findings are confirmed by the work of Eyre and Suchman. Whereas Wendt and Barnett focus on capital-intensive militarization writ large, Eyre and Suchman focus squarely on three distinct weapons types, namely armored personnel carriers, propeller aircraft, and supersonic aircraft. They find evidence that a recent history of warfare increases state-level inventories of all three weapons systems, that Cold War alignment increases state holdings of supersonic aircraft, and that state membership in international organizations, a proxy for a state's "level of institutionalism", increases supersonic aircraft inventories. This leads them to conclude that advanced weapons systems, particularly supersonic aircraft, serve a symbolic function. These weapons act as a signaling mechanism to the rest of the international community expressing the sending states' commitment to modern military means and methods. States acquire advanced weapons out of obligatory action – a desire to adhere to the modern nation-state model (Eyre and Suchman 1996). Acquiring the newest, most advanced military equipment produces an aura of modernity and the illusion of military capability.

Eyre and Suchman diverge slightly from Wendt and Barnett on one important point. Wendt and Barnett emphasize the importance of domestic political legitimacy. For them, the adoption process is driven by a desire to sell the government and its politicians to an internal audience. The adoption of modern military technology is designed primarily for the purpose of enhancing the profile and power of the civilian and military leadership. Eyre and Suchman do not dismiss the domestic component, but they do amend it by noting that a state's standing internationally and among its peers is just as, if not more, important. In order to be recognized as a modern state by the community of modern states, advanced armaments need to be secured and displayed for all to see. This explains why, for instance, many underdeveloped states in Sub-Saharan Africa maintain only a handful of advanced aircraft. This small collection of aircraft is "too few to offer any substantial strategic or tactical benefits…but enough to constitute a reasonable airshow" (Eyre and Suchman 1996, 93).

Norms can also shape national force structuring decisions, even to the detriment of military effectiveness. Farrell finds, for instance, that in its early post-revolutionary period the Irish Army consciously chose to adopt a conventional model of national defense that differed widely from the guerilla tactics of its predecessor the Irish Republican Army (2001). Even though the IRA's asymmetric approach had ultimately succeeded in wrestling sovereignty away from the British, the newly established Irish government felt it necessary to revert to conventional force structures and strategies despite a glaring weakness in conventional arms and equipment. Thus, the desire to adhere to the norm of conventional warfare and conventional military force structures overcame a rationalist calculation favoring a policy of asymmetric defense (Farrell 2001).

The desire to develop the appearance of a modern nation state - to adhere to the norm of military modernity - drives political leaders to pursue expensive, sophisticated and, ultimately, symbolic weapons systems. Military aircraft are just such a system.[35] We would expect, then, that states concerned about their status as modern states would be more likely to pursue airpower. But how does one measure a state's concern for status?

Eyre and Suchman offer one approach based on a state's level of "embeddedness" in the international system. The logic holds that states that are more concerned about status will generally be those that are more engaged with the international community. States that remain distant from the international community are, in so doing, displaying their lack of concern over foreign perceptions of themselves and disinterest in their national status relative to their peers. By contrast, those states that actively engage with the international community on a regular and ongoing basis have an incentive to enhance their relative standing among their peers in order to gain more influence over international decision making and to gain leverage or standing within international institutions. A state's level of engagement with the international community is synonymous with its embeddedness in international institutions. This concept is then quantified by measuring the number of intergovernmental organizations (IGOs) a state is a member of in a given year. Altogether, then, the greater the number of IGOs a state is a member of, the greater its level of international engagement, the greater its incentive to enhance its relative status, and the more likely it is to pursue status-conferring weapon systems like military aircraft. This leads to the following hypothesis:

H_9: States with greater concerns over relative national status (as measured by high IGO membership) are more likely to pursue military airpower

35 Eyre and Suchman argue that supersonic aircraft are symbolic and propeller driven aircraft are not. I agree that this applies in modern times. But in the early aviation period, before jet aircraft, all aircraft were imbued with symbolic meaning. Even more so when their capabilities were limited and effectiveness uncertain.

So, if security, resource, regime, and status elements drive a state's interest in military innovations, what factors determine the rate and extent of innovation diffusion? One major factor is geography. The ability to observe the actions and behaviors of neighboring states is easier than monitoring the activities of those on the other side of the globe. For instance, in the Americanist literature geographic proximity is a key determinant in explaining public policy diffusion patterns across U.S. state governments (Walker 1969). Specifically, Berry and Berry find that innovations travel fastest among states within a defined region like the Northeast or Midwest (1990). Of course, the notion that regional proximity accelerates diffusion internationally is very much a realist proposition. Indeed, hypothesis two is designed to test this assertion explicitly.

American domestic policy diffusion studies do, however, offer other insights into policy diffusion processes. One of the leading theories in this area is referred to as the 'national interaction' model. The 'national interaction' model focuses on the influence of cross-border communication networks of state officials working in a particular public policy area (i.e. environmental issues, public health, education policy, etc.). These officials gather at national conventions and association meetings to exchange knowledge and share their experiences in crafting and implementing various policy solutions. State-level policy specialists learn from one another, take "best practices" back to their home states, and then rally their fellow in-state policymakers around the most appealing innovations (Berry and Berry 2007; Mintrom 1997).

While it is one thing to share intimate details on primary school education policy, it is quite another to openly divulge sensitive information on matters of national security. To posit an "international interaction" model of policy diffusion challenges the realist assertion that states consistently maximize their relative capabilities (Mearsheimer 2001). Empirically, though, this is quite common. Major military powers like the United

States, Russia, and Britain share defense information and technical assistance with friendly governments on a regular basis. The United States International Military Education and Training program (IMET) is, for example, designed explicitly for this purpose (See DISAM "Green Book" 2012). Gatherings of civilian and military officials at international conferences on specific military issues, including weapons systems and defense strategies, operations, and tactics, are relatively common. Thus, the logic of innovation diffusion at the American state level has an imperfect, though still valuable, application to the international arena.

At its core, the national interaction model argues that American states with the most actively engaged public officials in inter-state affairs are the most receptive to innovations. Greater interaction results in quicker innovation adoption. In international relations, then, we would expect that those countries with officials that interact most frequently with their counterparts abroad would be quickest in adopting military innovations. One way of measuring this is by looking at the number of diplomatic connections a state maintains. In this study a diplomatic exchange is defined as having diplomatic representation at either the charge d'affaires, minister, or ambassador level with another country. A large number of diplomatic exchanges means a state has diplomatic representation at multiple levels in a large number of countries (See Bayer 2006). The greater the number of diplomatic exchanges, the more innovations these officials are exposed to, and the more opportunities there are to bring these innovations back to the home government. Airpower being one such innovation, we could expect that states with greater diplomatic presence abroad are more likely to adopt military aviation as a means of making war.[36] This leads to the following hypothesis:

[36] I include foreign military representatives (mainly attaches) within the broad umbrella of diplomatic presence. Diplomatic exchange is therefore a proxy for both political and military representation.

H_{10}: States with greater numbers of diplomatic exchanges are more likely to adopt military airpower

II. The Internal Political Dynamics of Innovation Emergence

Each of the hypotheses discussed so far is applicable to both the initial period of airpower diffusion in the early 20th century and the later period of airpower diffusion in the late 20th century. These hypotheses will we tested using quantitative methods based on two newly constructed datasets in the following Chapters 4 and 5. The final hypothesis is only applicable to the period of innovation emergence (1908-1914) and will be addressed in the case study in the following chapter. The focus of this hypothesis is on the internal political dynamics within the state and how pressure from different segments of society drive military innovation adoption. The discussion that follows builds upon the vast bureaucratic politics literature focusing on weapons development and national adoption.

The bureaucratic politics literature rests on the assumption that policy decisions, like the decision to purchase a particular weapon system, are the result of competition between sub-national institutions and organizations. This competition, whether driven by resources, authorities, or reputation, culminates in the selection and promotion of certain innovations over others. Military innovations, like all policy decisions, are not the result of rational calculation and directed action but rather the outcome of a series of contests among bureaucratic actors and domestic constituencies (Allison and Zelikow 1999).

The bureaucratic politics literature is bound together by a common emphasis on second-image type explanations (Waltz 1954). Though state action may be influenced by international events political decisions are, in the end, a product of domestic political processes. Bureaucratic politics theorists agree on this point. The tension comes in trying to assess the relative importance of sub-state actors. Which actors are most influential in deciding the shape, size, and composition of military forces? Which organizations and institutions ultimately succeed in adopting their preferred military innovations? In his review of the literature, Adam Grissom finds that, in general, the competing claims of bureaucratic authority coalesce around three distinct categories: the military services, the civilian leadership, and private civilians (2006).

Given that military innovation deals with matters of armed conflict, one would assume that the military services would exert a great deal of influence over the innovation adoption process. Indeed, their influence, specifically the manner in which they generate requirements for new systems, has been the subject of considerable interest among researchers and analysts (Ball 1994; McNaugher 1989; Else 2007). Broadly speaking, one finds that the requirements generation process is molded by competitive inter- and intra-service dynamics (Grissom 2006). The United States military offers several examples. For instance, Michael Armacost argues that American nuclear forces in the 1950's were shaped by Army and Air Force competition over the development and control of intermediate range nuclear weapons (1969). At the time, the Air Force held a monopoly on the U.S. nuclear arsenal. This monopoly brought with it a large influx of defense dollars. For the Army, land-based missiles offered an opportunity to claim jurisdiction over a portion of the nuclear arsenal. Doing so would increase the Army's mission scope while also improving its bargaining position in Pentagon budget battles. Seizing upon the opportunity provided by this new technology, the Army leadership approved and fast-tracked development of the Jupiter intermediate range ballistic missile (IRBM). The Air Force responded by accelerating its Thor IRBM program. Ultimately, the competition failed to produce a winner. Both systems were subsequently adopted (Armacost 1969). Though not the most efficient solution, the inter-service competition did produce a pair of innovative weapon systems.

An episode involving the Air Force and Navy played out similarly. As with the IRBM program, the Air Force was interested in sustaining its dominance over nuclear forces by expanding its portfolio with the Minuteman inter-continental ballistic missile (ICBM) program. The Navy responded by pushing its Polaris submarine-launched ICBM. Neither service relented. Congress refused to intervene on the behalf of either system resulting in yet another set of parallel systems designed to meet a similar requirement (Sapolsky 1972).

Though the competitive battle over service missions and resources can lead to acquisition inefficiency, this need not always be the case. In the mid 1970's the U.S. Air Force developed the A-10 attack aircraft as a means of preempting the Army's foray into the close air support mission area with its AH-56 attack helicopter. The Army program was soon shut down. The A-10 then went on to a distinguished career providing major contributions in Operations Desert Storm, Iraqi Freedom, and Enduring Freedom (Horwood 2006). Here inter-service competition resulted in a useful innovation that both retained the Air Force's historical jurisdiction over fixed-wing aircraft and provided the Army with a reliable, purpose-built close air support system.

At the sub-national level, the military services act strategically in their resource battles with one another. This competition involves a variety of methods for extracting a greater share of total military spending. The process usually starts with the specification of service requirements for new or existing military missions. In developing these requirements the services use several strategies to promote their interests including: (1) structuring requirements in a way that emphasizes preferred mission-types over less desirable mission-types, (2) creating expansive requirements that encroach on other service mission areas, or (3) adding or shifting requirements when alternative programs are cut back or eliminated, (4) promoting multiple, overlapping systems to mitigate the political risk of program elimination, and even (5) writing requirements in a manner that intentionally sabotages a particularly undesirable weapon system (Lebovic 1994). Each of the services then proposes its own innovation as the best possible solution to national security problems. Thus, the services seek to substitute their own preferred weapons in place of alternatives offered by competing services or the civilian leadership (Lebovic 1996).

In his comprehensive study of British and U.S. military innovation processes, Stephen Rosen explores how innovation advocacy occurs within the services themselves. For Rosen, military innovations emerge when entrepreneurial senior officers take it upon themselves to advocate for new doctrinal concepts. This process requires cultivating support from fellow like-minded officers. Together a small cadre of individuals must "implement a successful strategy for gaining political control over their service on behalf of [a] new way of war" (Rosen 1988, 142). Internal coalition building takes place in an environment of competing intellectual approaches. The ideas that lie upon firm empirical grounding and have the most effective advocacy coalition succeed. Once an innovation takes hold, senior converts institutionalize the innovation by establishing new promotion pathways for junior officers. These pathways allow a constituency to develop. This constituency carries on the ideas and concepts after its originators depart (Rosen 1991).

Interestingly, Rosen claims that attracting civilian support for a particular innovation can actually undermine an officer's efforts. He reasons that military leaders are more inclined to respect the arguments and opinions of their fellow officers. The military as whole - and the officer corps specifically - prides itself on its professional credentials, most importantly its expertise in matters of war and conflict (Huntington 1957). According to Rosen, civilian meddling in military affairs threatens this claim by eroding the military's preferred separation of civil and military responsibilities. Though often benign in intent, civilian intervention can bring an unintended backlash against both an innovation and its military proponents (Rosen 1988). The perception of civilian interference hinders what might otherwise be a useful military solution.

Rosen's argument contrasts sharply with Barry Posen's work on strategic and doctrinal innovation in the interwar period. Posen argues that militaries are, by nature, conservative organizations (1984). As such, military personnel are inclined to adopt offensive strategies because offensive tactics promote battlefield predictability while limiting civilian interference. Military organizations are, therefore, hesitant to accept new strategies and disruptive technologies that increase uncertainty – particularly when these innovations may affect their natural offensive bias (Van Evera 1984; Snyder 1984). In order for innovation to occur the military must experience a wartime defeat, or civilians must intervene, or both (Posen 1984).

A wartime defeat calls into question the competency of military commanders, their leadership capabilities, and their strategic planning processes. During the tumultuous post-defeat period a reflective look at strategic and tactical failures leads to a reappraisal of existing doctrinal concepts. This opens the door for new military methods and technologies. Old ideas on how best to defend the state are purged while innovative, novel solutions are given new life. For instance, German defeat in WWI brought about the massive reorganization of German military forces and, along with it, an infusion of new doctrinal ideas and concepts. This infusion included a string of innovative technological and operational solutions adopted by the Wehrmacht, refined in the Spanish Civil War, and put into action in WWII (i.e. Blitzkrieg) (See Millett and Murray 1996).

In the absence of defeat, military innovations often require action by civilian leaders to overcome bureaucratic obstacles. Here the "outsider" aspect of civilian administrators can have a positive effect. Un-indoctrinated in the stale thinking of military men, an enterprising civilian politician can take up the cause for a particular innovation. The politician must then sell the innovation to the military community. The odds of success in this endeavor are enhanced if the civilian intervener can co-opt military allies, or "mavericks", willing to take up the charge (Posen 1984). With the backing of the right military officials a civilian can gather the political capital necessary to induce change.

In separate works, Debbie Avant and Kurt Lang come to a similar conclusion. Avant compares how variations in governance structures, specifically the separation of legislative and executive powers, influences British and American doctrinal innovation. She finds that the bifurcated authorities of the American constitution increase the detachment of the U.S. military from its civilian overseers. This leads the U.S. military towards a more insular mode of thinking thereby decreasing its receptivity to new ideas. By contrast, the British governance model, one in which executive and legislative powers are fused, encourages a greater degree of civilian involvement in doctrinal formulation. The civilian influence produces more innovative, flexible strategies. The British military is, therefore, more flexible than its American counterpart owing to the greater influence of civilian political officials (Avant 1993). Lang seconds the notion that civilian intervention can stimulate innovative thought. In studying the organizational dynamics of the American military enterprise, Lang finds the hierarchical, traditional nature of the military limits its capacity to anticipate change. Innovative concepts and technologies are instead "promoted by civilians, who have often shown themselves more sensitive to changing needs than the professional military leadership" (Lang 1965, 857).

Finally, the source of innovation need not lie solely with the government. Though strategies, doctrine, and tactics remain the responsibility of the military, the equipment, weapons, and technology used to carry out these methods are products of the private sector. The machines and equipment for making war - the hardware of conflict - come from the scientists and engineers of the defense industrial base. This community can serve as a source of military innovation. Evangelista finds, for instance, that the potential of tactical nuclear weapons was first identified by atomic scientists working in defense and industry laboratories in the early 1950's (1988). Their ideas for small-scale battlefield nuclear systems in the form of nuclear tipped artillery shells and short-range rockets quickly diffused to their receptive military counterparts before moving up the chain to top policy decision makers (Evangelista 1988). Tactical nuclear weapons were not, then, a direct response to service requirements but rather a new civilian-generated technological solution to the broader problem of battlefield interdiction.

Private influence on military innovation is not limited to scientists and engineers. There have been several occasions in which the mass public has exerted its influence over military strategies, tactics, and weapons procurement and deployment decisions. In the 1980's, for instance, mass demonstrations and an outpouring of opposition to nuclear missiles in Europe forced the United States and its allies to reassess plans to deploy Pershing missiles to Germany and the United Kingdom. The ferocity of the public opposition toppled the government of Helmut Schmidt and pressured the U.S. into pursuing the Intermediate-Range Nuclear Forces Treaty with the USSR (Joffe 1987; Bohlen et al. 2012). Another, more distant example can be seen in the influx of private donations for naval construction during the United States' Quasi-War with France in 1798. The public fundraising campaign collected several hundred thousand dollars, enough to purchase nine new warships for the U.S. Navy. These additional warships boosted total U.S. naval strength by 75% (12 to 21 ships) (Sechrest 2006). A similar outpouring of support and donations from public members of the German *Flottenverein* (Navy League) at the turn of the century spurred on German dreadnought construction (Boyne 2003, 42). In each of these cases military procurement and deployment decisions were shaped not by strategic factors but rather by mass public support (or opposition) in the form of public demonstration and supplemental funding.

The obvious tension in this literature lies in assigning cause to one of the three primary sub-state actors (military services, bureaucrats, or private civilians). Scholarly disagreement here offers an opportunity to interject into the debate. In the qualitative case study I seek to identify which actor(s) were most influential in persuading their national governments to adopt military aviation. This leads to the following three interrelated hypotheses:

H_{11}: *A. Civilian leaders were the driving force behind initial airpower adoption*

B. Military leaders were the driving force behind initial airpower adoption

C. Private civilians were the driving force behind initial airpower adoption

III. A Final Note on Excluded Alternatives

In reviewing the military innovation literature two categories of theory were consciously rejected for theoretical and methodological reasons: strategic culture and technological determinism. Strategic culture has been cited in a number of recent studies as a driver of military innovation (Adamsky 2010; Gray 1999). Scholars in this area argue that state behavior is driven by internally generated beliefs, values, and perspectives derived from historical circumstances and country-specific characteristics. According to Alistair Johnston, strategic culture describes a set of "pervasive and long-lasting strategic preferences" that manifest themselves in the language and communications of political and cultural leaders (1995, 46). These preferences determine the state's orientation towards the military and violent conflict writ large. This orientation systematically biases national security decision making in one direction or another.

Strategic culture is a useful counter to the standard rationalist argument but it suffers from three major deficiencies. First, the term strategic culture is unequivocally vague. Johnston describes strategic culture as "an integrated 'system of symbols' (e.g. argumentation structures, languages, analogies, metaphors)" that establishes strategic preferences about the use of force (1995, 46). But what constitutes a relevant 'system of symbols'? Political literature in nearly every culture contains a host of argumentation styles, analogies, and metaphors. How is one to discern with any sort of definitiveness those elements that represent the state's shared cultural values and core strategic preferences? How can one objectively identify these elements?

Even if one could accurately identify these strategic preferences their influence on military innovation is unclear. What types of cultural characteristics encourage or discourage innovation? Which way does the causal arrow point — does strategic culture shape innovation? Or, do intellectual and technological innovations modify the state's strategic preferences? Finally, accepting the logic of strategic culture infers that each state possesses its own unique cultural motivations. If true, then there is little value in attempting to identify systemic trends in military innovation diffusion. The circumstances of each adoption are individually unique. This negates the utility of large-n studies. Ultimately, strategic culture was excluded for lack of conceptual clarity, uncertain implications, and methodological incompatibility.

Technological determinism is less a coherent literature than an intuitive observation of global technological development. The basic argument goes that military innovations are the inevitable result of ever progressing technological achievement (Smith and Marx 1994). Advances in science and manufacturing produce new technologies that influence the trajectory of history by pushing decision makers in a particular direction to the exclusion of other possible avenues. New technological capabilities beget new forms of warfare and thus the nature of warfare is determined by the level of technological development of the day rather than by the social interaction that occurs between and within states.

The primary fault of technological determinism lies in its dismissal of human agency. Technological innovations do not just happen. They do not simply appear independent of an initial "innovator". Someone, somewhere must actually go about crafting a revolutionary concept or building a revolutionary machine. These individuals create and develop their innovations to "do something". They have a purpose to guide them in their creative process whether it be money, fame, function, or some combination thereof. Likewise, technological innovations do not grow organically. They are consciously constructed to solve problems – in this case the problem of national defense. Though governments may not always correctly anticipate the nature of military innovations they most certainly do impact the trajectory of defense investment (Dombrowski and Gholz 2006). This trajectory then determines the flow of technology in one direction or another.

Chapter 3: Innovation Emergence – The Invention of Airpower

This chapter examines the emergence of the airpower innovation and its early diffusion patterns. The purpose is to gain an understanding of how the technology of military aviation first came about, how it was received by the international community, and what factors promoted or suppressed national interest in airpower capabilities. The chapter is split into five sections. The first section provides a brief background on the invention of military aviation and the establishment of the first functional military aviation unit. The second section describes the process of early airpower diffusion in Europe. The third section looks at initial airpower adoption patterns outside of Europe. The fourth section synthesizes this information in order to test the evidence against the competing hypotheses presented in the previous chapter. The final section draws general conclusions on national-level airpower adoption decisions by the major powers in the pre-WWI era.

I. The Invention of Military Aviation

Modern military airpower traces its lineage to the first heavier-than-air flying machines developed by Orville and Wilbur Wright in their bicycle shop outside of Dayton, Ohio. The Wrights began their efforts by building and testing a series of gliders at the sand dunes around Kitty Hawk, North Carolina in 1901 (Howard 1987, 32). After constructing several unpowered machines, the brothers attached an engine to their most advanced glider and took to the skies on December 17th, 1903.[37] By the end of the year

[37] Today the Wrights' claim to have produced the first manned, heavier-than-air aircraft is widely accepted. At the time, though, there was some controversy as to whether the brothers had actually beaten another American, Secretary of the Smithsonian Institution Samuel Pierpont Langley, into the sky. In October 1903, a full two months before the events at Kitty Hawk, Langley attempted to launch an aircraft from a floating platform in the Potomac River. The aircraft immediately dove into the water and was a complete loss. Despite this failure, and the terrible newspaper coverage it received, the Smithsonian Institution asserted that Langley's craft was the first viable, manned, heavier-than-air craft in history. Furious over this decision, Orville Wright refused display the Wright *Flyer* at the Smithsonian Institution for several decades. The controversy did not end until

these experiments had progressed into a series of short, powered flights. The first of these traveled no more than a few dozen feet. By the end of December the Wrights' longest flight lasted nearly a minute and covered some 852 yards (Scott 1995, 158). These initial hops, though primitive in nature, confirmed that the basic principles of heavier-than-air flight were sound and that manned flight was, indeed, an achievable goal. The brothers quickly returned to Ohio and went about improving their designs and filing for a formal patent with the United States government (Crouch 2003, 81-82).

In January 1905, the brothers set about marketing their new and improved third generation *Flyer* to the U.S. military. Confident that "governments often appropriate inventions useful in war," Orville and Wilbur wrote their local congressman, the Honorable R. M. Nevin, for assistance in securing a government contract (Budiansky 2004, 24). In their letter to Nevin, the Wrights argued that their *Flyer* could "be made of great practical use in various ways…(including) that of scouting and carrying messages in time of war" (Scott 1999, 137). Clearly the Wrights understood the enormous potential of their invention as a reconnaissance and communications platform. Unencumbered by natural terrain features, a pilot could ride aloft over enemy lines free to observe troop dispositions, movements, and maneuvers. Relayed back to base this information would prove invaluable to commanders in the field. Recognizing this, Rep. Nevin quickly forwarded the brothers' request to the United States Department of War (Howard 1987, 164).

The proposal was directed to the U.S. Army Board of Ordnance and Fortifications. The Board was not, however, overly impressed with the Wrights' proposition. Unclear exactly what the Wrights were offering and wary of their claims of success, the government refused to commit to purchasing an aircraft. In Major General

1942 when Smithsonian officials finally admitted their error and acknowledged the Wrights' rightful place in aviation history (Howard 1987).

J.C. Bates's reply to the Wrights, the general acknowledged that the department received many unfulfilled requests for funding and that this particular proposal was inadequate in its current state. He noted that before the Board could consider the matter further the Wrights would have to "furnish (the) Board with the approximate cost of the completed machine, the date upon which it would be delivered" along with drawings and descriptions necessary for its construction (Scott 1999, 139). The Board, it seems, simply refused to believe that the Wrights had produced a successful flying device.

When negotiations with the U.S. government floundered the Wrights turned their attention abroad. Great Britain was the first of the major European powers to take interest. The British representative, Lieutenant Colonel John Edward Capper of the Royal Balloon Factory, arrived in the fall of 1904. Capper met with the Wrights at their shop in Dayton with the intent of confirming the rumors of American aeronautic success while simultaneously assessing the comparative progress of British aviation. The Wrights were hesitant to share much with the Lieutenant Colonel and refused to allow him to inspect their device. Instead, the meeting initiated a lengthy negotiation process with a divided British War Office (Gollin 1979, 81).

From 1905 to 1908 other European governments expressed a mild interest in the Wrights' machine. In France, at the time the leading challenger to the American monopoly on heavier-than-air flight, there were doubts about the validity of the brothers' achievements. Among the elite there were those who simply refused to believe that the Wrights, a rather inauspicious pair of American bicycle makers, could have conquered the mystery of powered flight. Led by the influential aristocrat and Aero Club president Ernest Archdeacon, skeptics intimated that the Wrights had lied about their aviation achievements and were, in fact, "outright frauds" (Hallion 2003, 214). Even among those who accepted the Wrights' claims there was a degree of confusion over what this new invention meant for the future of warfare. Conservative military thinkers viewed the aviation community, vested at the time in kites, gliders, and other contraptions, as primitive in nature and inherently dangerous. Indeed, future French Commander on the Western Front General Ferdinand Foch let it be known that, in his opinion, "the aeroplane (was) an interesting technology, (but) its practical value was zero" (Buckley 1999, 33).

The breakthrough came in early 1908. That year the Wrights' request came to the attention President Theodore Roosevelt who immediately instructed the War Department to produce a set of requirements for a military flying machine (Gross 2002, 17). Given the embryonic state of aviation at the time the level of performance specified was surprisingly high. The Board of Ordinance and Fortifications offered a contract of $25,000 for an aircraft capable of carry two people aloft for over an hour over a minimum distance of 125 miles (Chenoweth 2002, 5).

The Wrights immediately went about modifying their aircraft to meet these requirements, the most radical of which was the addition of a position for a passenger/observer. By September the brothers had finalized a testable machine for Orville to exhibit at the Army's proving grounds at Ft. Meyer in Virginia. Over the course of ten days Orville conducted a series of evaluation flights demonstrating the speed, endurance, and carrying capacity of their *Flyer*. After exceeding all specified requirements the Army issued a contract for the first functioning heavier-than-air craft in history. This aircraft, dubbed the *Military Flyer,* was to be delivered in August 1909.[38] As the U.S. Army moved forward in the field of fixed-wing aviation, the European powers followed closely behind. Though French aviators trailed the Wrights considerably, interest in aviation among the French public was high. This enthusiasm for heavier-than-

[38] See *United States War Department Army Signal Corps Correspondence with Orville and Wilbur Wright* January-September 1908. Available in the Wilbur Wright and Orville Wright papers, 1809-1979 collection at the United States Library of Congress. Accessible at: http://hdl.loc.gov/loc.mss/mwright.04164

air flight brought Wilbur Wright across the Atlantic to perform a series of flying demonstrations at the Auvours race course outside of Le Mans in August 1908. Wilbur's demonstrations, occurring at the same time as Orville's presentation to the U.S. Army, offered the European aviation community a glimpse at how far American aviation had progressed.

To this point, European aviators were capable of producing only short, erratic flying exhibitions with little stability or control over any considerable distances. Most flights lasted no more than a few minutes.[39] With their wing-warping principle firmly tested and confirmed, the Wrights were capable of sustained, controlled flight over several miles. On August 8th 1908, Wilbur took to the sky over Hunaudieres, circled the track twice while performing a series of banked turns and maneuvers before softly touching down in the grass. He followed this with additional demonstrations including much longer flights and more courageous maneuvers. This culminated in a two hour and twenty minute flight at the Auvours artillery testing ground later that fall (Gibbs-Smith 2004, 234). The European aviation community was shocked. Indeed, one skeptic, the popular balloonist Edouard Surcouf, proclaimed that underestimating the Wrights was "the greatest error of the century" (Villard 1987, 54).

The Hunaudieres/Auvours demonstrations were followed by two major aviation events in the summer of 1909. The first was the crossing of the English Channel by French aviator Louis Bleriot on July 25th. The feat garnered considerable attention from the press and public alike (Wohl 1996, 56-58). In Britain, news of Bleriot's crossing was met with a mix of admiration and anxiety. Now capable of traversing great distances over natural terrestrial impediments, the aeroplane presented a potential threat to civilian

[39] At the time of Wilbur Wright's demonstration the longest European flight was roughly 20 minutes by Henry Farman in a Voisin-Farman I-*bis*. By contrast Wilbur Wright took an improved *Flyer* model aloft for nearly an hour some *three* years earlier in October 1905. See Gibbs-Smith 2004, 234.

populations. The specter of large scale aerial attack was now within the realm of possibility. Historian Percy Walker argues, for instance, that "the shock to the British people was comparable to that produced in the United States by the Japanese attack on Pearl Harbor in December 1941" (1971, 330). After centuries of security afforded by the English Channel, it was now feared that aviation would make Great Britain "no longer an island" (See Gollin 1984, 43-46).

Bleriot's crossing was followed one month later by a massive air exhibition at La Champagne outside Reims, France. Bringing together the top aviation talent from around the world (with the crucial exception of the Wrights themselves), the 'Grand Aviation Week' involved several days of aviation competitions and exhibitions capped off by the 'Grand Prix de La Champagne'. The winner of the Grand Prix received the James Gordon Bennett Trophy and a $10,000 prize (Crouch 2003, 117). The competition was fierce. Aviation records in speed and endurance were broken and re-broken several times over the course of seven days. More importantly, however, the air show provided an opportunity for aviators and enthusiasts to come together to observe recent aviation innovations, compare their own progress and designs, and bring home new ideas and concepts for further experimentation.

Bleriot's flight in July and the Reims airshow in August accelerated the growth of the burgeoning aviation industry. Both events showcased the increasing capabilities and safety of heavier-than-air flight. Interest in individual aircraft ownership spiked as a good portion of the European elite turned their attention away from automobile races and towards aerial competitions. The increase in demand came quickly. Within two days of Bleriot's successful landing at Dover he received some 100 orders for copies of his monoplane design (Hallion 2003, 257). Playing on his victory in the Reims air races, the American Glen Curtiss took several orders for his *Reims Racer* in late 1908. The Wrights took a similar tack, traversing Europe and providing demonstrations to public and private citizens alike. The brothers also established the Wright Company in Germany with the backing of local investors and immediately began producing models for sale (Morrow 1993, 18).

Taken together the Wrights' demonstrations at Hunaudieres, Bleriot's cross-channel flight, and the Reims air meet represent a year-long turning point in military aviation history. From late 1908 to the start of 1910, heavier-than-air flight evolved from a limited curiosity to a broadly accepted technological marvel. In January 1910, the official journal of the Aero Club of the United Kingdom, *Flight*, captured this sentiment in its opening recap of the previous year: "phenomenal progress has been made (in 1909)….where at the beginning of the twelve months the number of confident flyers and their machines could almost be reckoned on the fingers of one hand, to-day (sic) their number must run well into three figures."[40]

This evolution is evident in the expansion of military aircraft acquisitions. In August of that year the first military aircraft was delivered to the U.S. Army. Two months later the French War Ministry released funds for the purchase of five military aircraft of varying designs (Hallion 2003, 264-265). Britain, Germany, and Russia followed shortly thereafter. Once the ball was rolling events proceeded quickly. As Budiansky notes, "at the start of 1909 there were 0 military aircraft worldwide, by 1910 there were 50, and by 1911 the device had been used in combat" (2004, 45). The expansion of aerial military forces continued up through World War I. On the eve of war in 1914, there were an estimated 1,000 operational military aircraft in service among the major belligerents (Budiansky 2004, 51).

II. The Evolution Airpower among the Major Powers

While the United States can rightfully claim to be the first airpower adopter it did

[40] "One Year of Flying and of 'Flight.' A 1909 Retrospect" *Flight* 53 (London, UK) 1 January 1909. Accessible at: http://www.flightglobal.com/pdfarchive/view/1910/1910%20-%200007.html

not maintain its lead in military aviation for long. The Wrights' aircraft was an excellent early achievement but it was, by the end of 1909, largely obsolete. New models of more capable aircraft from burgeoning manufacturers like Farman, Voisin, and Bleriot could equal or surpass the *Flyer's* performance (Gibbs-Smith 2004, 234-235). The Wrights' refusal to part with their pusher type biplane configuration and rail launching system meant that the center of aeronautic innovation shifted to Europe. Indeed, the French quickly established a series of new aviation records and began producing a variety of models for military and civilian customers. Owing to the country's healthy lead in engine technology, the French aviation industry became the global leader in airplane production in the pre-war era (Boyne 2003, 44).

The strength of the French aviation industry was largely the result of a favorable political environment. French government subsidies in the form of lucrative contracts for aircraft manufacturers drove the expansion of the domestic industrial base from 1910-1914. While other neighboring governments hesitated, the French War Ministry upped its aircraft acquisitions from five aircraft in 1909 to several dozen in 1910. The size of these orders multiplied several times over the next few years such that by 1914 the French possessed 162 aircraft in military service (Kennett 1991, 21). Though slightly less in number than its chief rival to the east, the quality of French aircraft was widely considered superior to that of the Germans, Austrians, and even the British (Morrow 1982, 12).

The French aviation community was also aided by the government's early investment in aeronautic research. In an effort to sustain the lead in aviation, the French government increased funding for the 'Establissement Militaire de Chalais-Meudon' and the 'Laboratoire du Champs de Mars'. The former became the primary aviation testing center for the French military. The latter, under the direction of famed engineer Gustave Eiffel, eventually evolved into the 'Institut Aerotechnique de l'Universite de Paris'

(Hallion 2003, 246). These organizations contributed much needed scientific and technical knowledge in the fields of aerodynamics, propulsion, and pilot safety. They also conducted materials testing in order to establish the tolerances of aircraft engines and airframe components. The data collected from the comprehensive testing program at Chalais-Meudon was then shared with private manufacturers who used this information to create safer, higher performing aircraft.

Eventually, with the buildup of French aviation forces came the need to organize men and machines within the broader military hierarchy. The first five aircraft purchased in August 1909 were assigned to the Army's Corps of Engineers under Major Victor Paul Bouttieaux (Christienne and Lissarague 1986, 35). This lot was designated for preliminary testing and, later, observation and reconnaissance duty. Shortly thereafter the French parliament allocated an additional 200,000 francs to the artillery section to create the Aviation Artillery Establishment (Christienne and Lissarague 1986, 36). The seven aircraft acquired with these funds served as artillery spotting aircraft.

A year after their initial acquisition the French Army leadership put their first aircraft to the test in maneuvers outside of Picardy in September 1910. Over several days a handful of planes attached to Army headquarters units were used to scout enemy positions and report on enemy troop movements. Despite some initial teething problems, the consensus among commanding generals in the field was that the intelligence gathered by airmen and their observers was, indeed, quite valuable (Cuneo 1942, 153). After watching the new aviation arm in action one observer, General Pierre Roques, reported to the French War Minister that he now believed that "airplanes are as indispensable to armies as cannon or rifles" (Morrow 1993, 15). Similar exercises were held the following year.

The maneuvers of 1910-12 provided a platform for experimenting with various small unit aviation arrangements. Through a process of trial and error the French Army developed the concept of the escadrille, or squadron, as the lowest tactical organizational unit. A typical escadrille consisted of 6 aircraft, all of the same type, flown and maintained by a consistent set of pilots and ground crews over the length of a deployment (Kennett 1991, 20). The size and composition of the escadrille maximized tactical flexibility while minimizing the logistical burden. By using standardized aircraft, equipment, and crews, mission planning became easier and more consistent while maintenance issues were reduced. The basic squadron/escadrille is, today, the standard method of organizing aviation forces worldwide.[41]

While France led the way in airpower development its rival, Germany, was not far behind. Throughout the pre-war period the Kaiser's government was a strong supporter of military aviation. The level of support did, however, vary significantly by bureaucratic department. For example, upon witnessing early flying displays in 1910, German General Helmuth Von Moltke, Chief of the General Staff, immediately requested the government allocate funds for the purchase of several Wright and Bleriot model aircraft. The Prussian War Ministry declined this request stating that, like the U.S. Army, they would not allocate funds towards what they believed was an immature technology (Cuneo 1942, 95-97). Still, Moltke persisted and eventually was able to use his influence to procure a handful of machines later that year. The following year the General Staff requested funding for 112 aircraft of various types. Once again the War Ministry resisted, choosing to set aside only enough money to acquire 34 aircraft (Morrow 1993, 20).

Eventually news of French aeronautic success in the Picardy maneuvers filtered into Germany. This forced the War Ministry to soften its opposition to fixed-wing aviation. From 1912-1914 the German air arm expanded rapidly, eventually becoming the largest aviation force in the world (Kennett 1991, 21). This quantitative advantage was,

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[41] Witness, for instance, the nomenclature and unit arrangements common among most modern airpower states. See *Jane's World Air Forces* (2013).

however, negated by the qualitative superiority of French aircraft. Historian John Morrow argues that the disparity in aircraft quality between Germany and France was the direct result of poor industrial policy and planning on the part of the Prussian War Ministry and General Inspectorate. Unlike the French War Ministry, conservative German acquisition officials were unwilling to offer funding for aviation experimentation, research, and testing. Instead they insisted upon purchasing only complete, functioning aircraft for a set price. Thus, the costs of research and development were left to the private sector which, as a result, opted for more proven airframes and engines over revolutionary, experimental designs (Morrow 1993, 54-55).

In terms of aerial doctrine, the German General Staff used a series of maneuvers in 1912, 1913, and 1914 to test various methods of organizing and employing aircraft in combat. Partly by observing French tactics and partly through their own experiences, the German Army settled upon the common escadrille/squadron-type organizational arrangement. Unlike the French, German squadrons were typically larger in size and were, at least initially, attached to the transportation corps rather than the engineering or artillery branches (Van Creveld 2011, 16). Also unique was the Prussian General Staff's steadfast insistence on the development and procurement of one particular type of aircraft – the reconnaissance airplane. These mostly two-seat models were designed to sacrifice speed and maneuverability for increased reliability, range, and stability (Morrow 1993, 38-39). Germany's most numerous aircraft, the Austrian-designed Taube, was emblematic of this approach. The Taube was a lightweight, monoplane design with unusual bird-like wings that performed unspectacularly but was relatively easy to fly and dependable over long distances. This somewhat mundane and obsolescent aircraft made up the bulk of the German air service in August 1914 (Morrow 1982, 8).

Though both France and Germany shared the escadrille system they differed in their approach to aviation doctrine, at least initially. In France, aviation assets were, after October 1910, consolidated under a single command, the Permanent Inspectorate of Military Aeronautics (Christienne and Lissarague 1986, 37). The consolidation stripped field commanders of their organic aviation elements, and instead, replaced this system with a more systematic (and temporary) method of detaching individual aviation units based on local needs. In theory, this decision would provide operational flexibility to campaign planners who could shift escadrilles between sectors based on the level of enemy activity. Eventually, though, political interference reversed this decision in April 1913. Though no structural changes were made to equipment or the escadrille, command of aviation assets was re-delegated down to army corps commanders and local administrators based on the sector(s) in which they operated (Christienne and Lissarague 1986, 46).

The German high command favored the decentralized model as well. When war came in August 1914 German aviation assets, both individual aircraft and whole squadrons, were parceled out to army and corps commands rather than consolidated under a single organization (Stokesbury 1986, 19). While aircraft procurement was directed by the German Aviation Inspectorate, these aircraft, once delivered, were no longer connected to the Army High Command. This method spread German aviation assets out thinly across the 25 Imperial Army Corps (Morrow 1993, 68). The ultimate result was an aviation contingent more closely aligned with tactical needs but incapable of large scale coordinated operations. During pre-war maneuvers a handful of commanders experimented with new strategies and tactics, though most ignored their aviation attachments choosing to use traditional cavalry units for scouting and reconnaissance missions (Cuneo 1942, 95).

Outside of the two continental powers military aviation developed steadily. Though lacking the industrial capacity and resources necessary to sustain a large aviation industrial base, the second tier powers, namely Italy, Austria-Hungary, and

Russia, contributed to the evolution and diffusion of airpower. For instance, in 1911 Italy became the first country to use the airplane in combat during its war with the Ottoman Empire in Libya. In October of that year the Italian Army landed near Tripoli and quickly established a local aviation facility. A few days later a handful of reconnaissance aircraft were sent across the Mediterranean. On 22 October the first military reconnaissance flights were undertaken by fixed-wing aircraft. The following month Italian aviator Lt. Guilio Gavotti commenced the first aerial bombing attempt in history by lobbing a handful of grenades upon a small Ottoman camp outside of Tripoli (Hippler 2013, 1). The primitive bombs did little damage but, in a sign of things to come, warranted surprise and derision among the continental public after Ottoman forces claimed that the explosives had injured innocent civilians in a local field hospital (Boyne 2003, 38). Italian commanders continued to employ aircraft over the Libyan desert up until the war's conclusion one year later.

Unlike Italy, Austria-Hungary and Russian contributed to military aviation not through experience, but rather by producing two influential aircraft designers. From Austria-Hungary came Igo Etrich whose Taube monoplane was widely popular among the sporting community and, as a result, was pressed into service as a "bomber" and reconnaissance aircraft from 1910-1915 (Norman 1968, 42). Indeed, when Lt. Gavotti dropped his grenades on the Ottoman camp in Libya he did so from a Taube. From Russia came a young ambitious engineer by the name of Igor Sikorsky. Though he would later found one of the most successful helicopter companies in history, Sikorsky's initial contribution to airpower came with the development of the first four-engine strategic bomber. This massive biplane, the *Ilya Muromet*, could fly for several hundred miles with a half-ton payload. Up to seventy of these machines were built from 1912-1917 and were used regularly by the Russian Imperial Army on the Eastern Front (Kennett 1982, 32).

While each of the second tier powers adopted aviation relatively early, their airpower capabilities were quickly outstripped by their larger, more industrialized allies. Austria-Hungary was, by 1914, almost wholly dependent on German aircraft manufacturers. In that year the Austrian War Ministry allotted less than a million marks to aircraft procurement. Contrast that with the nearly 26 million marks spent in Germany (Morrow 1976, 52). In this case, a peculiar domestic political arrangement, one in which military funding of any kind required approval from two separate parliaments, inhibited the development of military aviation. While the Austrian Reichsrat regularly proposed large funding increases for training and procurement (including aviation), the Hungarian Diet denied each of these requests in turn, only succumbing to political pressure on the eve of battle in mid-1914. The Hungarian leadership (rightfully) believed that their Austrian compatriots might use such an expanded army against them in an attempt to undo the power sharing arrangement enshrined in the Compromise of 1867 (Wawro 2014, 24). Adding to the weak financial situation was a generally conservative, technology-averse mindset within the Austrian officer corps at large. Nowhere was this more evident than in the Emperor himself who, upon witnessing the demonstration of an experimental armored car in the 1906, declared that "such a thing would *never* be of any military value" (Wawro 2014, 58).

In spite of her weak industrial base, Russia was favorably disposed toward aviation and the Russian government devoted a relatively large proportion of the defense budget to aircraft acquisition from 1912-1914. This money was used to purchase mainly French aircraft and engines and pay for maintenance personnel and pilot training. The first Russian Army aircraft was, in fact, a French Bleriot model purchased in 1910. The Russian government retained close ties with the French military aviation community up until 1917 when military events and political turbulence severed the connection (Hardesty 1998, 19).

In the formative years of military aviation the leading technological and doctrinal concepts all emerged out of continental Europe. The two English speaking powers, the United States and Great Britain, failed to match the quantity and quality of aircraft coming out of French and German factories. When war eventually came, Great Britain had less than 100 aircraft available while the "United States had a grand total of 8" (Kennett 1991, 21). In both countries nearly all the aircraft in service were domestically produced models inferior to their German equivalents. For example, the most common model in the British Royal Flying Corps was the B.E. 2c, an underpowered observation aircraft with terrible handling characteristics. Nicknamed "the Quirk", the B.E. 2c was resoundingly hated by British pilots. As the aviation journal *Flight* noted in 1954, "Probably no other airplane of the Great War, Allied or enemy, earned so much vilification and obloquy as were heaped upon the hapless 'Quirk.'"[42]

In both the United States and Britain the slow evolution of airpower was the result of direct government action, or more accurately, inaction. In Britain the government's attitude toward aviation shifted over time. The British military's first experiments in aviation began with the founding of the Royal Balloon Factory at Farnborough in 1904. Initially charged with assessing dirigibles and lighter-than-air craft, the facility soon became the chief research and testing center for fixed-wing aircraft as well. In these early stages, before the unveiling of the Wrights' device at Le Mans, British aeronautic research was rudimentary in nature, relying almost exclusively upon the haphazard experiments of Samuel Franklin Cody and John William Dunne (Crouch 2003, 94).

Soon, though, news of Wilbur's demonstrations brought serious aeronautic research to the fore. In 1908 the British Parliament appointed a committee to study the

[42] J.M. Bruce, "The B.E.2 Series" *Flight* (2 April 1954) pp. 393. Accessible at: http://www.flightglobal.com/pdfarchive/view/1954/1954%20-%200873.html

issue of military aviation and its relevance to British military policy. The Report of the Sub-Committee of the Committee of Imperial Defence on Aerial Navigation found that fixed-wing aircraft presented little threat to British forces, little practical offensive utility for British commanders, and were generally not worth the cost when compared to 'lighter-than-air' alternatives. Therefore, the committee recommended that Parliament "stop all the money at Farnborough (the British aircraft factory) which was being spent on aeroplanes" (Gibbs-Smith 2004, 148). The evolution of the airplane was to be left to the private sector.

The committee's findings had a cooling effect on British aviation that, while only temporary, did indeed set the British Army back at least a year. Government funding for aircraft testing dried up immediately. Official sentiment shifted in November 1911 when a similar committee was convened to take up the question of aeronautics based on recent technological advances. The second committee on Aerial Navigation reversed course by calling on the government to establish both the Royal Flying Corps and Royal Naval Air Service (Driver 1997, 214-219). The committee also called for the renaming of the Royal Balloon Factory to the Army Aircraft Factory and, later, the Royal Aircraft Factory. The name change reflected the new focus of the facility on heavier-than-air flight (Hallion 2003, 277).

The Aerial Navigation Committee's reappraisal of airplane development shifted the onus from industry to the government. Initially, the private sector shouldered the burden of researching, designing, and building new aircraft designs. The establishment of the Royal Aircraft Factory seized this role for the government. This maneuver produced an unexpected trade-off. In the near term, government-produced aircraft were more closely aligned with military requirements. In the long term, though, the government's direct competition with private manufacturers inhibited the growth of the domestic aviation industry. At a time when private demand for airplanes was negligible, the lack of government contracts starved domestic aviation companies of the means to survive. Thus, the British entered the war in 1914 with a dearth of quality aircraft and engines relative to France and Germany, but also an industrial handicap that would take time to recover from (Morrow 1993, 41-45).

The British Royal Flying Corps (RFC), like its aircraft, developed slowly during the immediate pre-war era. Officially established in May 1912 the unit was quickly provided with a few dozen aircraft and new recruits for pilot training. The collection of men and machines were primarily Army but included some naval aviators and, following the French model, was sub-divided into squadrons. The RFC grew considerably over the next few years. In August of 1914 the Royal Flying Corps could claim to have some 50-100 aircraft ready for operations on the continent (Kennett 1991, 21).

The acquisition of aviation equipment did not in itself solve the issue of airpower strategy. British aviation historian R.A. Mason argues that by 1914 the basic tenants of modern airpower doctrine had been developed by a small cadre of British military and civilian thinkers. These tenants were not, however, understood nor incorporated into the wider RFC community and went unheeded in the first months of the war (Mason 1986). Worse yet was the failure of the Army leadership to articulate a strategy for the employment of aviation assets in support of ground operations. Indeed, Hugh Trenchard, the RFC Commander at the time, recalled later that upon hearing of the declaration of war he was immediately given the keys to the confidential war plans box. The next day he found the box was full of shoes (Stokesbury 1986, 24).

If aviation progress was slow in Britain, it was glacial in the United States. Almost immediately after its initial aircraft acquisition in August 1908, the United States began to fall behind the European powers. While France, Germany, and, later, Britain devoted vast resources to aviation, the United States government refused to expend limited defense dollars on aircraft purchases and pilot training. Case in point, Congress failed to appropriate a single dollar to aviation from 1908-1910. In 1911 it allocated a paltry $25,000 for the purchase of five machines (Gross 2002, 21). The lack of official support continued up through the early part of the war. From 1908-1913 the U.S. government appropriated a grand total of $435,000 to aviation. This put it far behind all of the major European powers and several smaller states including Belgium, Spain, and Greece (Crouch 2003, 134-135).

Much like Germany and Britain in the early pre-war period, the United States left aviation research and development to the private sector. Whereas the European powers eventually shifted policy by guiding industry and nationalizing production, the United States refused to interfere with its domestic manufacturers. It did not provide subsidies nor establish official scientific research and testing facilities until 1915.[43] The lack of industrial policy was exacerbated by a lengthy, acrimonious legal battle between the Wrights, Glenn Curtiss, and several smaller airplane manufacturers (Shulman 2002, 171-180). The Wrights' vigorous enforcement of their aviation-related patents severely restricted other American manufacturers from designing or selling their own machines. Specifically, the Wrights' 1905 patent describing the use of wing-warping and ailerons gave them, in essence, a monopoly on methods for controlling aircraft along the longitudinal axis. If competing firms wanted to use either innovation they were required to pay 20% royalties to the Wright Company for *each aircraft produced* (Shulman 2002, 184). The legal proceedings bounced around the courts from 1911-1916, only ending when the U.S. government, on the verge of war, consolidated all outstanding aviation patents under a single unified licensing agreement (Johnson 2001, 114). Together the weak government funding, lack of industrial guidance, and the protracted legal battles

[43] This year Congress allocated funds for the establishment National Advisory Committee on Aeronautics (NACA). NACA would go on to play a major role in American aviation development in the inter-war period and eventually evolved into the National Aeronautics and Space Administration (NASA). See Gorn 2001.

curtailed early American airpower adoption. The American aviation industry would not recover until after 1918.

Though aircraft and equipment were in short supply, the small collection of U.S. Army and Navy pilots with access to Wright and Curtiss models were surprisingly inventive in experimenting with their machines. For instance, in November 1910 Eugene Ely became the first aviator to take off from a ship at sea when he piloted his Curtiss biplane off a temporarily converted cruiser outside of Norfolk, Virginia. Three months later he successfully landed on another cruiser outside of San Francisco (Sitz 1930, 5). In 1909, Lt. Jacob Fickel took a rifle aloft as a passenger and showed spectators below that it was possible to hit ground targets with a firearm from a moving aircraft. Similarly, Col. Isaac Lewis took a machine gun up with him to demonstrate its effectiveness as a weapon against ground troops in simulated strafing attacks (Gross 2002, 23). These experiments, though forward-looking, were mostly one off events with little follow up attempted on the part of the Army or private manufacturers to develop aerial armaments into useful combat systems. Most of the doctrinal and technological innovations that would come to dominate aerial warfare were developed in Europe from 1914-1917. Only later were they adopted by the United States.

When American soldiers went to war in 1917 the Army did, however, have a modicum of experienced pilots and ground crews after having been involved in a series of small-scale conflicts with Mexico from 1912-1916. The first missions involved aerial reconnaissance duties around the Texas border under the command of the Wrights' first student Lt. Benjamin Foulois. Owing to the poor state of Army equipment, American pilots were forced to fly sorties in a single Wright pusher model rented from a wealthy local patron, Mr. Robert Collier of *Collier's Magazine* fame (Hurley and Heimdahl 1997, 18). Tensions between the U.S. and Mexico cooled for a time before ramping back up after a military coup toppled the Mexican government in February 1913. This time the

U.S. Army detached the First Aero Squadron (having adopted the French escadrille model) of nine planes and eight pilots to Texas City. Of the eight pilots involved only three had completed pilot training (Hurley and Heimdahl 1997, 30).

The campaign was an unmitigated disaster for American military aviation. Six of the squadron's eight planes were rendered useless in the first two weeks due to mechanical problems. Those that did manage to get off the ground were not powerful enough to fly over the Sierra Mountains and did not have the endurance required to fulfill their intended scouting role (Corum and Johnson 2003, 17). Pilots and ground crews complained loudly to local newspaper reporters about the inferiority of their equipment and the dangerous conditions of their assignment. Eventually the commander of the American intervention force, General Pershing, dismissed the squadron, sending the pilots and ground crews back to their training facilities near Sam Houston, Texas (Gross 2002, 26).

The poor state of American aviation is summed up in the U.S. Air Force's official history: "during its first decade…the Army air arm's progress was excruciatingly slow, plagued by miserly funding, an indifferent Army, contentious manufacturers, and no serious threat to national security to spur development" (Hurley and Heimdahl 1997, 15). The U.S. Army, little interested in spending heavily on military equipment generally, and particularly on untried and unproven technologies, preferred to devote its limited resources elsewhere. Eventually American indifference would come to haunt the Army as it mobilized for war in 1917. Neglected for so long, the great industrial might of the United States was unable to contribute much to the war in the air. American aviation had fallen so far behind its allies that by war's end the United States could not produce a single frontline fighter or attack aircraft. From the declaration of war in April 1917 to July 1918, none of the U.S. combat squadrons flying overseas were equipped with American aircraft (U.S. War Department 1918, 55). Yankee pilots were, instead, almost entirely reliant on French Neiuports, SPADs, and British Sopwiths.

The early period of airpower proliferation ended with the outbreak of WWI. In a scant six years (1909-1914) the number of airplanes in service globally had grown from barely a handful to nearly a thousand. The expansion and evolution of the air weapon was most remarkable in Europe. In August 1914, Germany and France led the world in aviation possessing some 232 and 162 serviceable aircraft, respectively (Kennett 1991, 21). Russia, with 190 machines, appeared strong on paper but was, in reality, a step behind the West European powers in aircraft quality, pilot training, and domestic airplane production (Kilmarx 1962). Great Britain, Italy, and Austria-Hungary had somewhere between 50 and 100 aircraft in varying states of readiness. Belgium possessed 16 aircraft while the Balkan states had no more than a handful a piece. The United States possessed only 8 (Kennett 1991, 21).

In addition to the aircraft themselves, each state developed airfields, maintenance facilities, training programs, and a cadre of pilots and aircrews to send these machines into action. Both the aircraft and the supporting structures were paid for out of roughly $86 million devoted globally to aviation from 1908-1913. Germany accounted for nearly a third of this ($28 million), France roughly a quarter ($22 million), and Russia around 14% ($12 million). They were followed by Italy ($8 million), Austria-Hungary ($5 million), Britain ($3 million), Belgium ($2 million), and Japan ($1.5 million). The remaining airpower states, mostly secondary European and Latin American countries, devoted anywhere from $40,000 to $700,000 to aviation (Crouch 2003, 134-135).

III. Early Airpower Diffusion Beyond the Major Powers

The first generation of airpower adopters acquired aircraft that were limited in capability and uncertain in purpose. This group included the major European powers, along with a few smaller European states piggybacking off the experience and technology of their neighbors. Romania, Belgium, Norway, and Sweden all observed the rapid diffusion of aircraft from the United States to France and from France to the rest of Europe. Made aware of these advances through their diplomatic representatives in Paris and Berlin, military leaders in each of these nations put in small orders with French and German aircraft manufacturers. In 1911, for instance, the Belgian government acquired a single aircraft, an airfield, and a flight school (Stokesbury 1986, 19). The Nordic countries did likewise shortly thereafter. While these orders were fulfilled, the smaller powers sent select officers to French and Prussian aviation schools for pilot training (Kennett 1991, 8).

The Balkan wars of 1912 and 1913 brought military aviation to southeastern Europe. The majority of aircraft were flown by French, Italian, German, and Austro-Hungarian mercenary pilots. These foreign aviators brought with them French and German aircraft and undertook reconnaissance and observation missions for their respective employers. The Balkan conflict served as a catalyst for airpower diffusion in the region and a proving ground for experimental concepts in airpower employment. Seeking to gain operational experience, the major powers, namely Russia and Germany, involved themselves into the organization and planning of local aerial operations (Paris 1991, 102).

The Ottoman Empire, itself having witnessed first-hand the capabilities of the aircraft via the Italian campaign in Libya, introduced a handful of aircraft into the Balkan conflict. Ottoman interest in powered flight dated back to the winter of 1909 when two competing French aviators, Baron de Cater and Louis Bleriot (of Channel crossing fame), traveled to Constantinople for the first flights on Turkish soil as part of a wider European aviation demonstration tour. The exploits of Bleriot and de Cater sparked the interest of the Ottoman General Staff which promptly dispatched a pair of officers to Bleriot's newly established flight school outside of Paris (Leiser 2005, 39). They returned a few months later to help train additional Turkish pilots and organize aviation support facilities. The Army's first batch of aircraft was delivered in 1912 (Wragg 2011, 246).

Outside of Europe and the United States there were only a handful of airpower adopters prior to 1914. In Asia, Japan made the first steps toward aviation when the government sent a pair of military attachés to France to test their newly ordered Bleriot monoplanes in November 1910.[44] Two months later, on December 19th 1910, Captain Yoshitoshi Tokugawa became the first Japanese military aviator when he flew a Farman biplane over downtown Tokyo. The government quickly moved to acquire additional aircraft and established both an Army Air Service and a Naval Air Service. By the end of 1911, small aviation units had been established within both branches along with the semi-autonomous aviation-enthusiast group called the Military Aeroplane and Balloon Investigation Society (Hallion 2003, 286).

The other major Asian power to pursue early aviation was the Kingdom of Siam in what is modern day Thailand. Like Japan, the Siamese government had, for much of the 19th century, taken a keen interest in adopting European administrative, economic, and military practices. In an effort to stave off colonization the Siamese sought to acquire modern European military equipment. So it was that when French aviator Charles Van Den Born announced his intention to tour Asia in his newly acquired Farman biplane the Siamese King quickly offered up funds for a local air exhibition (Young 1995, 1).

The week-long Bangkok Aviation Meeting commenced in January 1911. This event, though presented as a meeting of sorts, was in reality an opportunity to showcase Van Den Born's single Farman for a throng of excited Siamese citizens. Over seven days,

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[44] See "Bleriots for the Japanese Government," *Flight* (12 November 1910) pp. 933. Accessible at: http://www.flightglobal.com/pdfarchive/view/1910/1910%20-%200935.html

thousands of onlookers descended upon the make shift airfield to observe Van Den Born's various displays of aerial acrobatics. Sufficiently impressed, the Army Chief of Staff Prince Chakrabongse, quickly dispatched a handful of young officers to France for flight training (Young 1995, 3). At the same time orders were made for 8 French aircraft of varying designs. In November three trained and certified pilots returned to Siam with the aircraft in tow. The Siamese Ministry of War promptly established the Army Aviation Section under the Inspectorate of Royal Engineers (Young 1995, 6).

Whereas the European approach to airpower had varied considerably by national disposition, in South and Central America the proliferation of military aviation followed a mostly uniform pattern. In nearly every case the national fervor for heavier-than-air flight was stoked by traveling demonstrations of French or American aviators representing commercial interests. One of the earliest of these involved a flight by two European aviators, Ricardo Ponzelli and Henri Bregi, over Buenos Aires in 1910 (Newton 1978, 10). Similarly, in January 1912 American Jesse Seligman went aloft over Costa Rica as part of a traveling exhibition for the newly established Moisant aircraft company (Hagedorn 2008, 53). These events enthralled the public (as they had in Europe) while garnering the attention of military leaders. The early exposure to aviation set the stage for later military acquisitions.

Many of the early aviation exhibitions were sponsored and supported by the newly established national aeronautic societies. Organizations like the 'Sociedad Nacional de Aviacion', the 'Sociedad Divulgadora de la Aviacion en Mexico', and the 'Aero-Club Brasileiro' actively cultivated interest in, and funding for, aeronautic events (Newton 1978, 10). The Latin American aviation associations, like their European counterparts, usually formed around a core of aviation enthusiasts and their small cadre of wealthy backers. In Brazil, the local aero club provided the funds necessary to send the country's first military pilot, Lieutenant Ricardo Joao Kirk, for training in Europe

(Hagedorn 2008, 42).

Across Latin America the usual pre-cursor to the adoption of military aviation was the establishment of the national flight training school. These 'escuelas de avician militaire' were often partially funded by aviation societies and were staffed with foreign aviators associated with companies trying sell their machines to local governments (Hagedorn 2008, 39-60). Their purpose was to train a handful of military personnel in aviation matters. The schools served as the primary conduit through which aviation knowledge was transmitted from the Old World to the New. In this sense, the diffusion of airpower across the Atlantic was but one more stage in the near century long dissemination of Europe military methods to South America (Resende-Santos 1996).

The natural evolution from flight training school to operational aviation unit did not always progress smoothly. In a series of cases, political or economic troubles intervened to slow the transition from training to active service. In Brazil, for instance, an ambitious partnership between the military and the commercial firm, Gino, Buccelli and Cia, produced an airfield, several hangars, repair facilities, and 10 new European aircraft under the title 'Escola Brailiera de Aviacao' at the Fazenda dos Afonsos. Though a grand endeavor by South American standards, the project ultimately failed. Government funding was cut after a short period of troubled operation resulting in the temporary suspension of Brazilian military aviation activities (Hagedorn 2008, 45).

IV. Testing the Hypotheses

The previous sections provided historical background on the invention of military aviation and its early proliferation and development as a means of warfare. The following section assesses the hypothesized explanations for airpower diffusion against the historical evidence. The focus of the analysis is on the major powers of era, namely the belligerents in WWI, and emphasizes airpower adoption intensity rather than time to adoption. As such, the case includes only the major European powers and the United

States. The use of airpower adoption intensity avoids those instances in which aircraft were acquired purely for experimental purposes and instead focuses attention on national airpower capabilities. In any case, a broader, system-wide analysis using the time to adoption method is conducted in the next chapter.

The notion that airpower will eventually diffuse across all states in the international system is supported by the evidence limited to this particular case (H_1). Though the diffusion process was drawn out over several decades, eventually all states in existence in 1909 established a functioning military aviation unit. The intensity of adoption did, however, vary considerably between states. Table 1 shows the relative commitment of each of the major powers to aviation in 1914.

	Total Aircraft	$ Spent on Aviation	Total Military Expenditures	% of Military Expenditures
Germany	232	28	1,785	1.57%
Russia	190	12	857	1.40%
France	162	22	1,235	1.78%
Great Britain	~75	3	1,679	0.18%
Austria-Hungary	~75	5	1,042	0.48%
Italy	~75	8	87	9.20%
United States	8	0.5	253	0.20%

Notes: ~ indicates estimates. Expenditures in millions of dollars.

Table 1: Airpower Commitment of the Major Powers Pre-WWI

At the start of the Great War, Germany led the world in total aircraft and aviation spending. Russia and France, second in each category respectively, were equally committed to airpower but differed in their approaches to achieving parity with the Germans. The Czar chose to emphasize quantity over quality and, as a result, amassed a considerable fleet of aircraft (190) at relatively low cost ($12 million). France took the opposite approach. The French War Ministry allotted some $22 million to aviation in the pre-war years and wound up with an end strength of 162 total aircraft. While the Russian government spent $63,000 per aircraft, Germany and France spent roughly double that ($120,000 and $136,000, respectively). Consequently, German and French aircraft were of higher quality and capability.[45]

Great Britain, Austria-Hungary, and the United States all trailed the others by a substantial margin. Whereas Germany, France, and Russia spent between 1-2% of their 1914 defense budgets on aviation, Great Britain, Austria-Hungary, and the United States spent no more than half a percent. The British case is particularly striking given that British overall military spending was second only to Germany but aviation spending as a percentage of military spending was last among the major powers. Only the United States, with the luxury of geography separating itself from European affairs, spent less. Note that with its low defense budget and moderate aircraft inventory and aviation spending, Italy appears the leading airpower advocate. Indeed, the Italian government quickly committed to military aviation and was first to use aircraft in combat in 1911. As a result, most of the aircraft in the Italian inventory in 1914 were older obsolescent models from the Italo-Turkish War (1911-1912) (Franks et al. 1997, 107-109)

The notion that states with a history of conflictual relations will more readily adopt airpower is partially supported by the evidence (H_3). Both France and Russia, two major early airpower adopters, experienced four militarized interstate disputes in the five years prior to 1909 (innovation emergence). So too did the United States, the quickest airpower adopter but also the major power with weakest adoption intensity. The rest of the major powers experienced between one and two MIDs over the same time period. Thus, the quantitative evidence on this matter is somewhat inconclusive.

The qualitative evidence shows, however, that with such a small sample the nature of certain key disputes may better explain airpower diffusion patterns. The Agadir Crisis of 1911, for instance, put France at odds with Germany, one major power against another,

[45] It should be noted that most Russian aviation spending went to importing foreign aircraft, mainly from France, and served as an indirect subsidy to the domestic French aviation industry (Whiting 1985, 3).

and came very close to sparking WWI.[46] The threat of war was such that the British felt it necessary to intervene, both to restrain French overreaction and to warn Germany of the potential consequences (Kissinger 1995, 197). Though war was averted the level of threat remained high long afterward. Similarly, the Russo-Japanese War, a singular dispute of immense consequence, exposed the weakness and technological inferiority of Russian military forces thereby enhancing the national feeling of insecurity (MacMillan 2013). Finally, the Italian intervention in Libya, a colonial campaign of limited objectives, provided an opportunity to experiment with aviation in practice. In this particular case, the conflict did little to raise the level of threat against the metropole but rather offered a testing environment in which aviation technology and tactics could be evaluated and assessed for future use.

The positive effect of enduring rivalries on airpower adoption is supported, though some qualification is required (H_4). Among the major powers all, save Austria-Hungary, were involved in an enduring rivalry in 1909. But not all enduring rivalries are created equal. In 1909 the United States' enduring rivalry was with Haiti, a state with 2% of the population and .5% of the trade of the U.S.[47] Though relations between the two states were rocky, Haiti hardly represented a serious threat to U.S. national security. The French-German rivalry, on the other hand, was longstanding (starting in 1830) and intense (major war in 1871 followed by war crises in 1905 and 1911). The proximity and relative parity of the rivals contributed to level of threat and meant that military developments in one state directly influenced those in the other. Indeed, as noted above, the sensitivity of Germany to French ambitions is evident in the German General Staff's intense interest in French aviation developments (Hallion 2003, 177). The intensity of this rivalry helps explain why both France and Germany were so apt to invest in

[46] This incident only inflamed Franco-German animosity from the earlier Moroccan Crisis.
[47] Enduring rivalries data are drawn from Klein et al. 2006.

airpower. Likewise, Italy and Russia, both of which were involved in rivalries with near-peer competitors were early airpower adherents as well.

The one outlier here is Great Britain. In 1909, the U.K. found itself in several enduring rivalries against multiple peer-competitors, namely Germany, Russia, and the Ottoman Empire. Despite this, Britain was the least willing of the major powers to spend on military aviation. The cause of this delay is not entirely clear. One explanation, based upon the report of the 1908 Aerial Navigation Committee, is that British lawmakers felt that aviation technology was too primitive to be worthy of public expenditure. Indeed, the haphazard experiments at the British Royal Balloon Factory (late re-designated the Royal Aircraft Factory) at the time instilled little confidence (Penrose 1967). Another explanation comes from Britain's unique position as a predominantly naval power, and thus its need to funnel capital expenditures towards ship construction. For British lawmakers, the German naval buildup presented the most serious threat to British national security interests. Indeed, it was the Kaiser's shortsighted attempt to challenge British naval supremacy that pressured the British government into the Entente Cordiale (Tuchman 1962). Consequently, British defense appropriators allocated a large proportion of the national military budget to dreadnought construction (Massie 1991). This was, of course, money that could have otherwise been devoted to aviation.

The diffusion of military airpower in the early 20th century followed a distinctly regional pattern, albeit with one major exception (H_2). The first airpower adopter was in North America. The U.S. adoption did not prompt immediate regional adoption, though in practical terms the number of potential military rivals in North America was negligible (essentially Mexico). However, fourteen out the next sixteen adopters were in Europe. It was there that aviation technology matured to the point of practical military utility via the efforts of small inventor-aviators in France, Germany, and to a lesser extent, Russia, Italy, Britain, and Austria-Hungary. The proximity of the smaller European powers to leading airpower nations and the availability of aircraft on the international market allowed for the rapid diffusion of airpower from France and Germany to Belgium, Spain, Denmark, Sweden, and the Netherlands (Hallion 2003, 279-283). Regional conflict, namely the Balkan Wars of 1912 and 1913, brought airpower to Eastern Europe (i.e. Romania, Bulgaria, Greece, and Serbia) in the form of Western European machines and mercenary pilots (Boyne 2003, 40).

Aviation was next introduced to Latin America where, again, it quickly spread across the continent. The manner of diffusion was, unlike Europe, surprisingly uniform. First flights were usually conducted by European aviators sponsored by wealthy local patrons and public aviation societies. The exhibition of European aviators and equipment led, eventually, to the establishment of military aviation schools like the 'Escuela de Aviacion Military', the 'Escuela Militar de Aviacion' and the 'Escola Brasileira de Aviacao' in Argentina, Bolivia, and Brazil, respectively (Hagedorn 2008, 39-45). While initially reliant on European and American instructors, most schools eventually produced enough local aviators to equip regular military aviation units and dismiss foreign pilots and support personnel. Reliance on foreign machinery, however, never fully subsided.[48]

The assertion that national military resource availability facilitated initial airpower adoption is supported, though the effect of resources on adoption intensity is less certain (H_5). Among the total collection of states 1909 it is clear that early adoption was associated with high defense spending. Witness the fact that 6 out of the first 9 airpower adopters were in the top 10 in military expenditures.[49] Among the major powers, though, overall defense spending had little relationship to airpower spending.

[48] Witness the inventories of modern Latin American Air Forces today. With the important exception of various Brazilian Embraer models, nearly all combat aircraft in the region are American, European, and Russian designs. See IISS 2013.
[49] This is explored further in the following chapter.

Table 2 lists the great powers by military expenditures and CINC score and airpower commitment. States that spent over 1% of their 1914 defense budget on aviation are classified as having high airpower commitment. The table shows an even mix of high and low airpower commitment among the major powers regardless of relative military expenditures. There also appears to be no link between overall national military capabilities (CINC score) and airpower commitment either. Clearly, the intensity of airpower adoption among the great powers was driven by factors other than national military power resources available.

	Military Spending Rank	CINC Score Rank	Airpower Commitment
Germany	1	2	High
Great Britain	2	4	Low
France	3	5	High
Austria-Hungary	4	6	Low
Russia	5	3	High
United States	6	1	Low
Italy	7	7	High

Table 2: Major Power Military Expenditure Rankings and Airpower Commitment

Total state population appears to have little bearing on airpower adoption. In general, the notion that smaller states will seek airpower capabilities to make up for their lack of manpower is not supported (H_6). In 1909, Russia had a population more than double that of the next closest European power, and was highly committed to the concept of airpower. The United States, the second most populous major power, had little interest in aviation. Germany, another relatively populous state, led all others in airpower spending and aircraft acquired. Meanwhile Austria-Hungary, with a population less than half that of Germany, devoted less than one third the proportion of defense dollars on aviation than its Central Power ally. Thus, there appears no pattern in the relationship between airpower commitment and national manpower reserves.

Only in Italy, which spent lavishly on aviation despite its vastly inferior defense budget, is there any indication that military leaders consciously pursued a capital for labor substitution policy. Indeed, major airpower theorist Giulio Douhet, commander of the Italian aviation battalion at Turin from 1912 to 1914, was firmly committed to the belief that "technology would compensate for Italy's inherent weaknesses in manpower and natural resources" (Meilinger 1997, 2). He argued this point fiercely, so much so that Douhet was eventually dismissed from command and threatened with court martial. In the aftermath the Italian high command, though interested in airpower generally, chose to emphasize lighter-than-air flight over fixed-wing aviation. Consequently, in 1914 75% of the Italian aviation budget went to purchasing dirigibles (Capellutti 1967, 66).

The assertion that military airpower, like other military innovations, will diffuse faster among allied states has no basis for support (H_7). The initial pattern of airpower diffusion in Europe shows little correlation with the dominant alliance patterns of the day.[50] This is not necessarily surprising given that the first aircraft sales were purely commercial in nature. Early aircraft were marketed by their inventors to both governments and private individuals with little restriction on technology transfer across international borders. Lacking either military foresight or the necessary regulatory capacity, most national governments chose to ignore the diffusion of technical information to neighboring states, regardless of whether they were allied or not. Witness the Wrights' initial sales attempts. While Wilbur Wright stated that he preferred to sell their machine to their own government, he had little qualms about taking their technology overseas (Scott 1995, 173). Ultimately, the Wrights "concluded a series of agreements with European firms for the manufacture of their aircraft and aero-engines under license in Britain, France, and Germany" (Collier 1974, 35). In so doing their commercial endeavor acted as a major communication channel through which technical aviation knowledge was transmitted across international borders.

[50] I am referring here to the Triple Entente (Britain, France, and Russia) and the Triple Alliance (Germany, Austria-Hungary, and Italy).

Eventually, though, alliance patterns did begin to impact aircraft purchasing decisions. Following the Agadir Crisis of 1911, when tensions in Europe hit their pre-war peak, political and military officials across the continent began to reassess their own military and economic vulnerabilities to potentially hostile trading partners. In France and Germany this led to national industrial policies designed to foster domestic aircraft production. This was particularly true in Germany where fiercely competitive aircraft manufacturers took to accusing one another of employing French engineers of questionable loyalties (Morrow 1976, 35). When Dutchman Anthony Fokker, Germany's great aircraft designer of WWI, first opened his factory in Johannisthal, he was forced to take on two native German partners to cover for his own foreign nationality (Morrow 1976, 43).

In Great Britain and Russia concerns over potential hostilities meant German aircraft were largely ignored, while French models were imported en masse. For the British the importation of foreign machines was a temporary measure until its own domestically produced models could compete on equal footing. The Russian government, on the other hand, recognized that with its relatively primitive technological base, it could match neither the quality nor the quantity of the aircraft produced by its Western neighbors. Consequently, the Czar committed his Army to French equipment, training, and personnel. Case in point, on the eve of war in August of 1914 the Russian Army had 244 total aircraft in service, 224 (92%) of which were French (Jones 1977, 19).

The members of the Triple Alliance acted similarly. Austria-Hungary, itself the weaker of the continental alliance partners, produced a small number of aircraft domestically but was, for the most part, reliant on the major German manufacturers to outfit its aviation squadrons. Even when one of its own citizens introduced the highly successful Taube, production quickly shifted to Berlin where the Rumpler Aircraft Construction Company took over the license and began selling updated models to both governments (Morrow 1976, 75). Italy, the poorest and most uncommitted of the major alliance partners, split its acquisitions between French and German companies. In its campaign against the Ottomans the Italian Army ultimately employed an eclectic combination of Bleriot, Nieuport, Farman, and Taube aircraft (Morrow 1993, 25).[51] By the time it entered the war in May 1915 the Italian Army's 'Servizio Aeronautico' had phased out its German and Austrian aircraft altogether.

Interestingly, the correlation between regime type and airpower adoption appears to be in the opposite direction than that anticipated in the initial hypothesis (H_8). Using the Polity IV data to classify the level of "democratic-ness", we find that among the seven major powers, two of the three democracies[52] exhibited little interest in airpower while three of the other four non-democracies were early airpower adherents. It seems, then, that the prospect of substituting capital, in the form of aircraft, for labor, in the form of soldiers, did not play a role in the force structuring decisions of the major democratic powers. If anything, the veracity of the anti-aviation elements in the British and American governments deomnstrates that spending on aviation was highly contentious when debated in an open, representative political setting (Gibbs-Smith 2004, 148). In these cases, when the policymaking process was open and inclusive, entrenched interests in the military could rally against spending on experimental weapons like aircraft that had neither a proven track record of effectiveness nor a natural domestic constituency to fall back on.

Devoid of the domestic political hurtles inhibiting military spending and its allocation, the autocratic governments could more easily raise and distribute funding for aircraft. Even among the autocratic powers varying levels of domestic constraint proved critical. For instance, in Russia Czar Nicholas II ruled with complete impunity and was,

[51] The first three were French, the latter Austrian.
[52] Democracies have a Polity score of 7 or higher. See Polity IV project.

unlike most of his Western counterparts, beholden to no domestic representative political body. In this environment, the Czar's personal interest in aviation could be indulged (and was) without restraint (Jones 1978, 19). This stands in contrast to the Austrian Emperor Franz Joseph who, despite his high title, shared control over the defense budget with the Hungarian Diet. In this environment, the Diet served as a check on increased military spending (despite the Emperor's best efforts) including his attempts to further fund aviation research. Thus, it seems that the capital for labor substitution rationale is not at work in the case of early airpower adoption. Instead, the relative ease of domestic policymaking, namely having fewer checks on military spending decisions (something more common in autocratic than democratic governments) was more important in determining the relative intensity of early airpower adoption.

The notion that states adopted airpower in order to enhance their relative status is generally supported (H_9). Each major airpower adopter did, however, have its own unique goals in mind. In France, for instance, national pride in French aeronautic technology, which was the most advanced at time, was widespread throughout society. The pubic infatuation with aviation, as evidenced by the reaction to Wilbur's Hunaudieres demonstration, Bleriot's Channel crossing, and, most importantly, the Grand Aeronautic Week in Paris, pressured the French government into pursuing aviation for military purposes against the better judgment of military leaders like Ferdinand Foch (Buckley 1999, 33). In France, the affinity for aviation was part of a wider obsession with advanced military technologies more generally. As historian David Herrmann notes, in the pre-war years "the French often appeared to be the most energetic pioneers of new technology, fertile in invention and inclined to be the first to field a new type of equipment that would not only add military capability but redound to the glory of the nation" (1996, 98).

In Russia status concerns shaped the Czar's attitude toward aviation in a slightly different manner. The humiliating defeat of the Russian military in its war with the Japanese in 1905 seriously damaged the country's reputation as a major power. The loss of the Baltic Fleet at Tsushima, in particular, cast doubt on the skill and technical competence of the Russian armed forces. While weaknesses in training, leadership, and tactics all contributed to the disaster, the inferiority of Russian equipment was particularly galling (Boot 2006, 192). Russian naval technology, thought at the time to be on par with its West European contemporaries, proved wholly inadequate. In the aftermath, the Czar looked for ways to reclaim Russia's major power status by acquiring newer, advanced military equipment. Aircraft were one such example. For the Army, then, the airplane "acted as a powerful symbol…of the ability to overcome Russia's chronic 'cultural stagnation and historical backwardness'" (Vitarbo 2012, 5).

Germany's aspiration to superpower status envisioned in the Kaiser's 'Weltpolitik' drove a massive expansion in German armaments spending. This opened up funding opportunities for innovative, experimental weapon systems like aircraft while simultaneously stoking populist support among the broader public. Though competing technologies like the German dreadnought fleet and the Zeppelin garnered most of the attention, public enthusiasm for fixed-wing aviation remained strong (Villard 1987, 228). Indeed, this support is evident the success of the Prussian-led National Aviation Fund in procuring several million marks in public donations for aircraft purchases in 1914 (Morrow 1976, 61).

The international interaction model, or the notion that greater diplomatic connections will lead to the quicker and more thorough airpower adoption, is largely supported by evidence (H_{10}). In the first decade of flight the primary inhibiting factor restraining the growth of aviation was a general lack of awareness and knowledge of what, exactly, aircraft were capable of. Ignorance of aeronautic developments on the part of both governments and the public can be attributed to several factors including the initial lack of reliable media coverage,[53] overly optimistic claims on the part of inventor-aviators and their promoters, and, most importantly, the extraordinary pace of technological advancement.[54] In this environment, European governments relied heavily on diplomats and military observers stationed abroad to cable back reliable information on aviation developments. National governments then used this information to assess the usefulness of aircraft for their own military purposes but also to gauge the level of interest expressed by potentially hostile militaries as well.

Opportunities for foreign officials to observe aircraft in action were plentiful. Major international airshows and exhibitions were useful venues for meeting individual inventors, inspecting the various models up close, and of actually viewing aircraft performance in flight. The most important of these was the 'Grand Aviation Week' in Reims, France in 1909. The Reims exhibition attracted a wide range of military and diplomatic officials from across Europe, Asia, and the Americas. Among these was the German attaché to Paris, Major Detlef von Winterfeldt, who cabled back to Berlin his assessment that "the French (had) made in a relatively short time enormous progress in the field of aviation technology" (Hallion 2003, 265). Thusly alerted, the Chief of the German General Staff promptly began lobbying the Prussian War Ministry for further aeronautic funding (Morrow 1993, 20).

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[53] News of the Wrights' first flights at Kitty Hawk was largely ignored by major media outlets with only small blurbs appearing in the Wrights' local newspapers the *Dayton Daily News* and *Cincinnati Enquirer*. The first full treatment of the Wrights' experience was published in an obscure local apiculturist publication entitled *Gleanings in Bee Culture*. See Scott 1995, 170.
[54] Case in point, Orville's first powered flight at Kitty Hawk lasted some 12 seconds and traveled a distance of 120 feet. By 1905 Wilbur could stay aloft for almost 40 minutes covering roughly 24 miles. By the end of 1908 the French aviator Andveour, flying a Wright model B, went aloft for 2 hours and 20 minutes covering a distance of some 78 miles. See Gibbs-Smith 2004, 234.

In military terms, the more useful foreign reports were usually filed by attaches and observers sent to monitor foreign maneuvers and active military campaigns. The most important of these was the Italian campaign in Libya. Observers from several nations traveled to Tripoli to witness the Italian aerial weapon in action first-hand. Local observations produced some useful intelligence. For example, in a confidential report to the French Ministry of War, one military observer stationed in Libya reported that, contrary to newspaper headlines at home, the use of dirigibles for bombing and ground attack missions had failed to produce any casualties nor any tactical advantage for the troops on the ground (Kennett 1982, 14). Lieutenant Marzac's assessment was helpful in that it confirmed the French Army's preference for heavier-than-air craft over dirigibles.

Another example was the British decision to send a military mission to Rome in April 1912 for the express purpose of gathering information on Italian aerial operations. The mission, which included future Royal Flying Corps commander Major Frederick Sykes, interviewed Italian pilots about their experiences in North Africa and reported detailed transcripts back to the British War Office in London (Paris 1991, 103). The evidence collected by Sykes' group was used to justify the expansion of the British air service. The preamble to the 1912 White Paper creating the Royal Flying Corps acknowledged as such when it noted that "the efficiency of the aeroplane for purposes of military reconnaissance has been proved both in foreign manoeuvres and in actual warfare in Tripoli…" (Paris 1991, 107).

The debate over which sectors of society were most responsible for national-level airpower adoption decisions is, as one might expect, complicated (H_{11}). My definition of an airpower adopter is a state that has acquired at least one fixed-wing aircraft and established a permanent military organizational unit to operate said aircraft. Both components of the definition require action on the part of political and military leaders to take place. Funds must be provided for purchase and individuals selected to facilitate delivery. Thus, even if their impact on the adoption decision is minimal, the political and military leaders of any state are at least partially responsible for the adoption decision. For the purpose of testing this hypothesis, then, the question is taken to mean which sector of society (political, military, or private) was most vocal in its advocacy for airpower adoption, and consequently, which sector most influenced the actions of the other two?

Put in these terms, the evidence clearly indicates that private sector interests were most influential in advocating for the adoption of military airpower. Civilian political officials and military leaders were, as a whole, mostly passive forces in the development and diffusion of aviation.[55] In broad terms, official government response to the invention of the aircraft was one of confusion and uncertainty followed by an uneasy acquiescence to the inevitability of technological advancement.[56] Only in France, where aviation matured the quickest, was the airplane seized upon as a potentially exploitable military innovation with any vigor. In Britain the official response, at least initially, was one of concern over the potentially disastrous impact of airpower on the nation's traditional pillars of national defense. As historian Malcom Cooper notes, Great Britain "stood to gain nothing by forcing a means of warfare which tended to reduce the value of its insular position and the protections of seapower" (1986, 2). These concerns were expressed in a July 1910 memo from the British General Staff to the government in which the military leadership lamented its inability "arrest or retard the…unwelcome

[55] Naturally an attempt to characterize an entire class of individuals as broadly defined as "political and military leaders" across a range of countries is bound to oversimplify matters some. Still, the general sentiment of the military and political sectors was made clear by the statements and actions of state officials regarding aircraft acquisition and funding decisions. This is what is presented here.
[56] The major exception here is American President Theodore Roosevelt whose aggressively progressive agenda and direct intervention spurred the Army on in its negotiations with the Wrights. See Gross 2002, 17.

progress of aerial navigation" (Morrow 1993, 21).

The lack of enthusiasm for aviation among politicians was usually linked to costs. The expansion of the battlefield into the third dimension meant the expansion of defense budgets to accommodate a new class of weaponry. For governments, money spent on aircraft was money diverted from other military accounts and domestic priorities. Even when money was earmarked for aviation it did not guarantee results. In the fall of 1903 the U.S. War Department awarded $50,000 to the head of the Smithsonian Institution, Samuel Pierpont Langley, for the purpose of building an aircraft. Langley quickly went about constructing an elaborate flying machine, the *Aerodrome A*, atop a complex floating launch platform on the Potomac River outside Washington (Hetherington 1999, 19-26). On October 7th 1903, with government officials and the media watching, Langley's craft slid off the platform and glided for a few precious feet before nose-diving into the river. The machine was a total loss. The following day the *New York Times* proclaimed, "Prof. Langley's Airship Proves a Complete Failure."[57] Langley's embarrassment stung the Board of Ordnance and Fortifications and cast a pall over the field of aeronautics.

Even after the Wrights successes became known, the argument was made that aviation technology was too primitive for use in actual combat. For instance, upon witnessing one of Orville's Ft. Meyer flights in September 1908, U.S. Secretary of War Luke E. Wright spoke for many when he noted that he couldn't "see that these aeroplanes (were) going to be especially practical...until they (were) further developed, I do not think they will be of much service from a military standpoint" (Crouch 2003, 8). Similarly, Britain's 1908 Committee on Imperial Defense Sub-Committee on Aeronautics, the body responsible for the recommendation ceasing all national spending

57 "Flying Machine Fiasco," *New York Times,* 8 October 1903 pp. 1.

on airplanes, justified its stance by arguing that aircraft had, at that time, not yet "emerged from the experimental stage" (Driver 1997, 209).

The widespread resistance of military officials to aviation was more complex.[58] A wholly new weapon of war, the airplane disrupted traditional service structures by competing for roles with other army and navy units. For centuries armies had been arranged into infantry, cavalry, artillery, and supporting elements. The airplane did not fit neatly into any of these existing categories. The prospect of using aircraft for scouting and reconnaissance negated the need for cavalry skirmishers. The potential of aerial bombing challenged the value and utility of the artillery in softening enemy positions and disrupting enemy troop movements. Powerful vested interests in both branches were reasonably concerned that this new class of machines could usurp their roles and responsibilities within the military hierarchy. As such, much of the established military community resented the embryonic air services, particularly when they went about lobbying for a greater share of defense resources (Johnson 2001, 8-9).

To make matters worse, there was, at the time, no cadre of experienced aviation officers, no roadmap for establishing an aviation arm, and no proper guidance on how to employ aircraft on the battlefield. Instead, those who chose to advocate on behalf of airpower usually did so at their own professional expense. Often these officers were labeled eccentric or uncooperative and deemed unfit for promotion (Boyne 2003, 41). For instance, when asked his thoughts on aviation in 1909 British General Sir Douglas Haig remarked that "flying can never be of any use to the Army" and that officers who learned to fly were "wasting their time" (Budiansky 2004, 47).

Where the politicians and generals waffled the public did not. Sparked by Wilbur Wright's display at Le Mans and fueled by sensationalist newspaper accounts, aeronautic

[58] A notable exception is Helmuth Von Moltke who, unlike many of his contemporaries, was aggressive and persistent in his pursuit of airpower.

events, and a stinging sense of national pride, the public fascination with flight became an almost transnational obsession. Public enthusiasm was evidenced by the enormous turnout at aviation events. For instance, over the course of a week an estimated 500,000 spectators paid to attend the air exhibition at Reims (Hallion 2003, 258). In London, French aviator Louis Bleriot's famous channel crossing aircraft was displayed in a downtown department store in the summer of 1909. For the few days it was on display Bleriot's primitive machine, which had only barely limped across the channel before crashing over the cliffs of Dover, drew a crowd of 120,000 paying customers (Penrose 1967, 88).

Seizing on the public fascination with aviation, newspaper publishers in New York, London, Paris, and elsewhere began offering substantial cash prizes for aerial competitions. Many of these awards were quite lucrative by the standards of the day. For example, the *Daily Mail* offered a healthy £10,000 prize to the first British aviator to fly from London to Manchester (Penrose 1967, 88). For the first circular flight of at least one kilometer the Aero-Club de France offered the Grand Prix d'Aviation Deutsch-Archdeacon grand prize of some 50,000 francs (Crouch 2003, 87). In the United States the *New York Times* awarded $10,000 to Charles Hamilton for the first flight from New York to Philadelphia and back (Gurney 1965, 12). Finally, in 1910 famed newspaper publisher William Randolph Hearst offered an astonishing $50,000 dollars to the first pilot to traverse the United States coast to coast in less than 30 days (Villard 1987, 136). To put this in perspective, the entire aviation budget of the U.S. Army in 1912 was only $125,000.

The most telling evidence of the public adoration for heavier-than-air flight was, however, the creation and spread of the national aviation fundraising campaign. Across Europe and in the United States aviation enthusiasts sought to harness the public's infatuation by soliciting donations for the express purpose of purchasing aircraft and equipment for their national military services. These campaigns were active in nearly every major European capital. For example, in 1912 the Italian Aero Club of Padua proposed a national subscription to secure 2 million lira in order to purchase 100 aircraft for the government. Within a few months the subscription had collected nearly twice that amount (Kennett 1982, 17). A similar experience was had in Germany where the National Aviation Fund raised some 7.2 million marks to finance the acquisition of 62 aircraft and the training of 162 pilots (Buckley 1999, 34). In Russia the Czar sanctioned the Imperial All-Russian Aeroclub to issue a subscription to create a national aviation fleet. Following on this path the Russian Grand Duke Alexander Mikhailovich took it upon himself to redirect some 1.7 million rubles in publicly solicited funds to aviation-related projects. Some of these funds were used to establish a flying school and construct airfield facilities, but bulk of the money was used to purchase Farmans, Bleriots, Antionettes and other French aircraft designs for military purposes (Jones 1978, 17-18). Altogether private fundraising campaigns contributed an additional $7.5 million to the burgeoning military aviation industry allowing for the significant expansion of national military aviation services (Crouch 2003, 135).

V. Case Analysis - Explaining Airpower Adoption Decisions

As might be expected the determining factors driving national level airpower adoption were not uniform among the major powers. For each state, the weight assigned to each determinant fluctuated based on the internal political atmosphere at the time and perceptions of the international security environment. This final section summarizes the basic rationale behind the airpower decisions made by each of the major powers.

France

French enthusiasm for military airpower was driven by (1) security concerns, specifically war with Germany, and (2) status concerns, namely a desire to sustain and build upon their lead in aviation technology. In 1909, French animosity toward Germany was nearing its peak. After the Agadir Crisis of 1911 it became clear that conflict with Germany was inevitable. Consequently, French military spending rose substantially along with its pursuit of new technologies.[59] The direction of additional funding towards aeronautics was the result of pressure from public advocacy groups. Aviation societies, newspapers, and public fundraising campaigns encouraged the government to sustain French leadership in aviation technology for matters of prestige. Indeed, when Wilbur's demonstrations exposed the initial inferiority of French aviation the revelation was treated as a national tragedy. A firm base of government support was sought to ensure French aviation would not suffer a similar embarrassment in the future. Public funding and pressure buttressed military and political aviation advocates, allowing the government to devote considerable funding to the burgeoning French aviation industrial base. Ultimately, France's pursuit of airpower was driven by its fear of Germany and its desire to retain its status as the leading aviation power of the day.

Germany

The German approach to aviation was similar to that of France, though with slightly different consequences. Rising tensions with its neighbors, mainly France but also Britain and Russia, increased German national insecurity thereby pushing up defense budgets and encouraging the pursuit of advanced technologies. These tensions served as the underlying driver of German weapons acquisitions. The pursuit of fixed wing aviation was largely a reaction to French aeronautic enthusiasm. The conservative nature of German aircraft acquisitions, namely the unwillingness to fund private

[59] Coming at the end of the second industrial revolution, this period in history is one in which technological evolution was rapid in several areas (witness the transformation of the capital ship from ironclad to dreadnought, or the invention of the automobile). As such, each of the major powers had an incentive to push the boundaries of military technology by pursuing new weapons that would provide an advantage on the battlefield. The puzzle is, therefore, why certain states (like France) invested resources in aviation over other alternative technologies.

experimentation and the preference for slower, more stable aircraft models, reflected the general staff's desire to maintain rough parity with the French rather than make a concerted effort to eclipse French aeronautic successes. As far as status is concerned, Germany was unique among the major powers in that German public enthusiasm for aviation was largely directed at lighter-than-air craft, specifically the Zeppelin. Ferdinand von Zeppelin's airships were enormously popular in Germany, symbols as they were of German nationalism, and were generously supported by the government (de Syon 2002). Fixed-wing aircraft received adequate funding and support, especially from the General Staff, though by comparison the influence of status concerns on German fixed-wing aviation was somewhat less than that of France.

Russia

The Russian approach to aviation was also driven by security and status concerns, though in this case the latter was more influential than the former. Russian insecurity, as evidenced by its multiple enduring rivalries, was exacerbated by the catastrophe of the Russo-Japanese War. In an effort to restore its damaged reputation, the Czar sought to mask his country's technical limitations by acquiring a large number of aircraft from Western Europe. The emphasis of these purchases was on quantity over quality, with the desire to accumulate a large inventory of aircraft taking precedence over individual aircraft performance. At the same time, the Czar invested little in domestic aviation manufacturing (outside of Sikorsky's small operation) indicating that his interest in long term aeronautic development was limited. The short sighted strategy of purchasing aviation equipment abroad indicates that the Russian government was more interested in collecting aircraft quickly rather than developing a sustainable aeronautic industrial base. This seems to indicate that the Czar was more concerned with repairing the image of the military and the illusion of capability in the short-term rather than investing in long term aviation research, development, and production.

Italy

Italian airpower adoption intensity was shaped by practical experience. While subject to the same rising tensions as the rest of continental Europe, the Italian experience in Libya was a more influential event in Italian aeronautic development. Putting into practice both the aircraft and dirigible, the Italian military had the luxury of assessing the military value of aviation in action very early on. This then empowered aviation advocates to push for the expansion of the air service. Men like Guilio Douhet and Gianni Caproni developed aviation tactics and equipment that helped justified national spending on aviation. But Douhet was not alone, like France, Russia, and elsewhere mass public interest and funding for Italian military aviation pressured the government into acquiring aircraft for military purposes.

Great Britain

While Britain was engaged in a serious enduring rivalry with Germany it did not pursue airpower with the same vigor as either France or Russia. British reluctance to invest in airpower stemmed from a general weakness in aviation technology and the competing resource demands of the Navy. Like Germany, Britain closely monitored aeronautic developments in Europe but refused to make a concerted national effort to challenge the French. The hesitance of the British government was based on a recent history of failures at the Royal Balloon Factory, specifically the inability to produce a functional domestic flying machine as late as 1910. The failure of government sponsored aviation development indicated to British lawmakers that aviation technology was too primitive to be of any use, and that further development should be left to the private sector. This attitude immediately set British aviation behind. More importantly, though, the small pro-aviation contingent in government had to contend with a dominant naval bias. The resource demands of the ship building program designed to keep up with Germany pre-empted any serious attempt to leap ahead in military aviation.

Interestingly, when Britain finally did begin to spend on airpower the shift in official opinion was the result of considerable public pressure. Unlike in France, this pressure arose not out of a pursuit for prestige but rather out of fear, fear of falling behind Germany and fear of the German Zeppelin menace specifically (Gollin 1981).

United States

As noted above, the official U.S. Air Force history of the pre-WWI period superbly summarizes the U.S. approach to aviation: "during its first decade…the (U.S.) Army air arm's progress was excruciatingly slow, plagued by miserly funding, an indifferent Army, contentious manufacturers, and no serious threat to national security to spur development" (Hurley and Heimdahl 1997, 15). The lack of a serious national security threat from any major power resulted in low military spending, leaving little excess for experimental aircraft purchases, and little incentive to innovate. At the same time, the peculiar patent battle between the Wrights and Curtiss had a detrimental effect on American aviation commercially and politically. The strict enforcement of the Wrights' patent protections inhibited aeronautic research and, subsequently, aircraft performance. Poorly performing aircraft (evident in the Mexican campaign) and the political sensitivity of aircraft contracts dissuaded an already indifferent U.S. Army from pursuing airpower. While public interest in aviation was high, as evidenced by the explosion in newspaper coverage, the lack of external threat inhibited the expansion of U.S. military aviation.

Austria-Hungary

Austria-Hungary is something of an outlier among the major powers. Though not technically involved in an enduring rivalry, the Austro-Hungarian Empire's geographic position put it at the center of the European powder keg. It was, like its continental European neighbors, in an intensely threatening environment. But unlike its neighbors the Habsburg monarchy suffered from three disadvantages in its pursuit of airpower, namely (1) a weak domestic aviation industrial base, (2) a divided and generally uninterested mass public, and (3) a conservative autocratic leadership system. Where France possessed a vibrant aviation industry with strong public support, Austria-Hungary possessed neither. Instead, the "other sick man of Europe" could produce few aircraft of any consequence (aside from the Taube), was racked by internal ethnic tensions[60], and driven by a military and political policy of stagnation. The preoccupation with maintaining internal order while sustaining the old imperial system produced an unfriendly innovation environment where tradition trumped technology. Ultimately, in Austria-Hungary the lack of a concerted domestic pro-aviation constituency and conservative political atmosphere led to disproportionately lower aviation spending relative to its rivals.

[60] These internal political fissures negated any shared nationalist sentiment toward aviation. Contrast this with France and Germany where nationalism and aviation were intimately linked.

Chapter 4: The Proliferation of Military Airpower in the Early 20th Century

The goal of this chapter is to examine the nature and rate of military airpower diffusion in the early 20th century. The chapter is divided into five sections. The first section provides a brief introduction to innovation diffusion concepts and terminology. The second section addresses the major methodological issues encountered in collecting, coding, and analyzing data on airpower diffusion. The third section provides an overview of the broad trends in airpower diffusion from innovation emergence to the present day. The fourth section tests the hypotheses from Chapter 2 to assess the impact of state characteristics on the rate and extent of airpower diffusion across the international system. The fifth and final section reviews the major findings and conclusions on the determinants of early airpower adoption.

I. Quantifying Innovation Diffusion

Before moving to the early airpower diffusion data it useful first to introduce the basic terminology used in quantitative innovation diffusion research. Most of the terms used in this research program are derived from Everett Rogers's *Diffusion of Innovations* (1962). Rogers defines diffusion as "the process by which an innovation is communicated through certain channels over time among the members of a social system" (1962, 5). This definition contains four key elements. Each of these elements is required for diffusion to occur. First, there must be an innovation. An innovation is "an idea, practice, or object that is perceived as new by an individual or other unit of adoption" (1962, 11). Second, there must exist one or more communication channels. A communication channel is a "process by which information is exchanged among the members of a social system" (Rogers 1962, 18). The communication channel serves as a means of facilitating the transfer of knowledge about an innovation from one unit to the next. Third, diffusion processes take place over time. Time can refer to the period between innovation emergence and innovation adoption for a specific unit, or across the system as a whole. Fourth, diffusion occurs within and amongst members of a social system. A social system refers to any collection of social entities (individuals, organizations, states, etc.) that are involved in some manner of "joint problem solving" (Rogers 1962, 23).

The innovation in this case is military airpower. Recall from Chapter 1 that military airpower is defined as the combination of fixed-wing military aircraft along with the personnel, organization, and supporting infrastructure required to operate said aircraft. Under this definition military airpower may be thought of as a two part innovation. The physical invention of the aircraft came with the Wright's first fixed-wing flights in December 1903. The organizational structure to support and operate military aircraft was invented 4 years later with the U.S. Army's establishment of the Aeronautical Division of the Signals Corps in August of 1907. The physical and organizational elements were fused two years later when the Aeronautical Division took delivery of its first aircraft in July 1909 (Budiansky 2004).

In the case of military airpower the channels of communication are numerous and varied. For any given state, there are a myriad of potential connection points: individual to individual, organization to organization, state to state, etc. Any attempt to uncover them all would be fool-hearted and, ultimately, bound to failure. Instead, this study seeks to uncover and highlight only those select few channels most responsible for the diffusion of relevant airpower information upon which action was taken.

The time element in this chapter focuses on measuring the variation in adoption rate across states (or units) at different points in the diffusion process. To organize this information, I rely on Roger's five broad unit categories based upon the rate at which these units adopted airpower. These categories separate each unit by their level of innovativeness, i.e. “the degree to which a (unit) is relatively earlier in adopting new ideas than other members of a system” (Rogers 1962, 252).

The five categories include innovators, early adopters, early majority, late majority, and laggards. The adopter categories are ideal types used to generalize about the characteristics and traits of the units in the system. Generally speaking, innovation diffusion follows a standard pattern. First, an innovation emerges and is adopted slowly by a select few. After a critical mass is reached and the adoption process accelerates rapidly. After the 50% mark the adoption rate begins to slow. This continues until the last remaining unit adopts. In most cases, the entire process resembles a normal distribution. The adopter categories are generated by taking successive standard deviations from the mean of this distribution and are broken down as follows: 2.5% innovators, 13.5% early adopters, 34% early majority, 34% late majority, and 16% laggards (Figure 1).

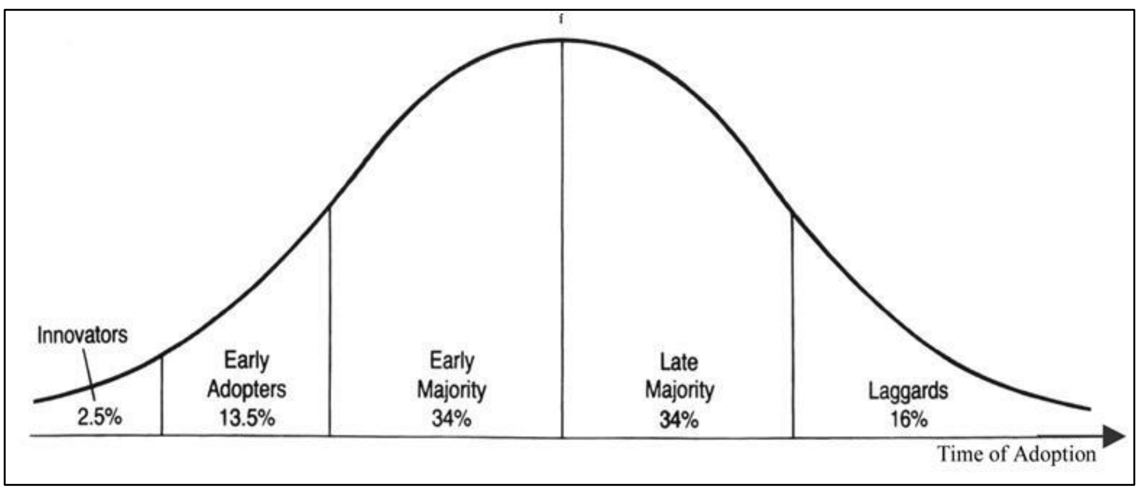

Figure 1: Rogers’s Innovation Adoption Categories

In this chapter, the international system is the unit of analysis and time, in the form of the innovation adoption rate, is the key measurement mechanism. In this case the time period under review begins with the first military aircraft acquisition in 1909 and runs through to the final early airpower adoption in 1956 (Morocco). In the next chapter the unit of analysis stays the same, though the airpower variable takes on a qualitative component and the time period under investigation spans the latter half of the 20^{th} century.

Finally, in the case of military airpower the social system required for innovation diffusion is identified as the international system of sovereign states. At first glance the idea of using the international system as a basis for innovation diffusion research seems rather simple. But using the entire collection of states presents a serious methodological problem. In most diffusion studies the population of the social system is static. For example, in Jack Walker's well-known study on the diffusion of state-level policy innovations in the United States, the total number of units in the social system is capped at 50 (1969). All 50 of the units are in existence at innovation emergence and at the time of the innovation's final adoption. This allows the researcher to graph the innovation-adoption curve over the entire adoption period. The stability of the social system allows for an accurate comparison of adoption rates from unit to unit.

The international system is more volatile. According to the Correlates of War State Membership dataset, the number of states in the international system quadrupled from 45 to 194 between 1909 and 2008 (2011). The growth in the total number of units in the social system greatly expanded the potential pool of military airpower adopters. Under normal circumstances in which membership in the social system remains constant, the adoption process would (ideally) form an S shape on a graph showing time and the number of adopters. The curve should rise gradually before a period of rapid acceleration in the adoption rate around the middle 50% point. After three quarters of the units in the system have adopted, the adoption rate should decelerate markedly before trailing off. In the international system new states emerge every year, sometimes multiple in a single year. The ever expanding number of units means that graphing the innovation adoption rate along an S-curve results in an extraordinarily long laggard tail. Ultimately, graphing airpower adoption over time we find the tail of the S ends up containing nearly three quarters of the total number of states.

This method of presenting the data is misleading. The units in the system are not comparable. Some states were in existence at innovation emergence while others did not become independent until much later. In order to account for this problem I chose to break the sample into two groups. The method used to analyze the first group, Group A, follows the more traditional approach to diffusion research by looking solely at the innovation adoption rate among those states in existence at innovation emergence (July 1909). The adoption process among this collection of units can be graphed along the normal S-curve. Rogers's adopter categories can also be clearly defined. Doing so provides a clearer picture of how military airpower was received among the system units, specifically which states quickly adopted airpower and which lagged behind. Classifying each state by the speed at which it adopted the innovation produces patterns among adopter categories. This process serves as a first pass at the hypotheses introduced in Chapter 2.

The second group, Group B, consists of those states that emerged as independent political entities after 1909. These states came into a world in which the innovation of military airpower already existed. Whereas the earliest airpower adopters had little knowledge of, or experience with, combat aviation, later adopters had a wealth information upon which to draw their conclusions on the efficacy of airpower. They also benefitted from rapid technological advances brought on by the Great War, specifically the development of distinct aircraft types based on missions and roles (Kennett 1991). As a result, political and military leaders within Group B states were able to make more informed decisions on airpower adoption based on a body of evidence rather than on technological potential alone.

The change in international opinion regarding military aviation began in November 1911 with the Italian Army's use of primitive Wright, Bleriot, and Taube model aircraft to bomb Ottoman forces in Libya. At the time reaction to the news of Italian aeronautic success was mixed. Initial news reports claimed that the Italian bombing raids had produced dozens of Ottoman casualties. More importantly, they claimed that the surprise aerial attack instilled fear among Ottoman forces resulting in a breakdown of military order and discipline. Later reports of military observers nearer to the events cast doubts on the veracity of the newspaper headlines at home (Boyne 2003, 38). It appeared that media accounts of the effectiveness of aerial attack had been greatly exaggerated. As a result, European military leaders of the day took away mixed messages from the conflict. Some more visionary leaders recognized that with advances in aeronautic technology, aircraft could play a major role in future conflicts. Other more cynical officers took away the opposite lesson, dismissing the utility of aerial attack under the presumption that air forces would drain undue resources from land and naval forces. So, while the Italian campaign in Libya served as the introduction of airpower to the international community its ultimate effect on the diffusion process was mixed at best (Budiansky 2004).

If the Italian campaign in Libya did not woo the undecided on the efficacy of airpower the Great War certainly did. WWI marked the definitive demonstration point[61] for military airpower by allowing for the deployment of aviation on a massive scale. Over the course of the war all of the major belligerents developed sophisticated aerial military

[61] The demonstration point "occurs when the potential of (the innovation's) full capabilities (are) reasonably known in the international system through an action by a first mover, rather than the capability merely being the subject of internal exercises or debates" (Horowitz 2010, 24).

forces. From 1914 on, aircraft were involved in every major battle on both the Eastern and Western fronts. The role of airpower expanded greatly as advancements in aeronautic technology enhanced the reliability and lethality of the aerial weapon (Norman 1968).

The maturation of military aviation in WWI altered the decision calculus of political and military leaders involved in airpower adoption. Military and political leaders in pre-WWI states made the decision to pursue airpower at a time when the technology was primitive, there was little evidence of weapon effectiveness, and the capabilities and limits of aircraft were largely unknown. Leaders in post-WWI states had the luxury of piggybacking off of the experiences of the belligerent states. These states better understood the role of aviation on the battlefield, its utility as an attack, reconnaissance, and transport platform, and the resource requirements necessary to field such forces. Simply put, post-WWI states knew that airpower worked and that it was important. The issue for this group of states was whether the resources required to field military aviation units were worth the investment given their own strategic, economic, and political circumstances. Conceptually, then, it is more appropriate to compare adoption patterns among the states within these groups rather than across groups.

II. Airpower Diffusion Data Collection and Methodology

When this project was initially conceived the intent was to track three distinct airpower indicators: military aircraft, military aviation units, and independent air forces. Specifically, I planned to track the first year of adoption of each category for each state in the international system at the time. For instance, in the United States the first military aircraft was purchased in 1909, the first military aviation unit established in 1909, and the independent Air Force created in 1947. Upon delving into the empirical research I soon realized that there were major methodological impediments to collecting the data in each category. Ultimately, I chose to drop the first (military aircraft) and third (independent air forces) variables from the analysis. Instead, I use the military aviation unit as the measure of military airpower diffusion. This section explains the rationale behind this decision.

The first category, first year of military aircraft acquisition, was dropped for several reasons. First and foremost was a lack of reliable data in this area, particularly in the early part of the 20th century. In general, records on aircraft purchases, transfers, and national inventories of aviation assets in the pre-WWI era were poorly kept. As a result, I encountered several sources with conflicting estimates of aircraft acquisition dates, numbers, and types – even on the militaries of the major powers. More recently organizations like the Arms Control and Disarmament Agency (ACDA), Stockholm International Peace Research Institute (SIPRI), and the International Institute for Strategic Studies (IISS) have taken a systematic approach to cataloguing arms transfers and maintaining longitudinal databases with this information. To my knowledge no such source exists for pre-WWI militaries. Secondary sources on the development of air power in this period contain some data but none provide a full system-wide analysis of aircraft diffusion.

The information available on international aircraft acquisitions in the latter half of the 20th century is generally more consistent, though political and historical circumstances complicate the data collection process. For instance, democratic states are generally open and transparent in their political processes including their arms production and purchase histories. This information is usually shared with international organizations like the U.N. Register of Conventional Arms and covered extensively by academic and commercial organizations liked SIPRI, IISS, and Jane's Defence Group. In autocratic states, however, information on military holdings is often hidden or intentionally obfuscated in order to mask the shape, size, and composition of the armed forces. This may be done as a way of hiding one's intentions or capabilities from potential adversaries.[62] In these cases, it is challenging to identify exact acquisition dates with any degree of certainty. Additionally, there are many states, whether nominally democratic or not, that simply do not keep consistent records on arms purchases. Particularly troublesome in this regard are former colonies in Sub-Saharan Africa and Southeast Asia where underdeveloped political institutions and the lack of a professionalized military result in inaccurate or incomplete arms inventory reporting.

The third category, first year of independent air force, was dropped for two reasons. First, the issue of finding reliable data that was consistent across multiple sources was, again, a major concern. The chief impediment here was in identifying the point at which an air service becomes "independent" from its original host service. For the major Western powers this information is widely available. The Royal Air Force, for instance, takes great pride in its status as the first independent air service in history (1918). But for smaller powers, the date when (and if) a military aviation arm separated from its original service is often unclear. This owes much to the national-level variation in military command terminology and the opacity of political regimes in non-democratic states. For instance, China, Laos, and Nepal possess aviation units that share the same name - Army Air Forces. In two of these three countries the air service commanders report directly to a single chief military officer rather than to their respective Army Chiefs of Staff. They are, for all intents and purposes, independent services. In the third,

[62] China is the prime example. Despite its massive size and growing international importance, quality intelligent on Chinese military assets is surprisingly thin. Witness the failure of U.S. defense analysts to anticipate recent advances in Chinese military aviation. See Wendell Minnick, "Are U.S. Defense Experts Getting China Wrong?" *Defense News* (1 December 2012). Accessible at: http://www.defensenews.com/apps/pbcs.dll/article?AID=2012312010002

Nepal, the aviation units are subservient to the Army (Wragg 2011). As an outside observer without an intimate knowledge of the military command structure of each state, it is difficult to classify one military air unit as independent against another. Again, this task is only complicated by data discrepancies between sources.

The second and more important issue relates to the purpose of this study. My interest is in tracking the diffusion of military airpower by looking at initial adoption patterns. I am less concerned about later developments in the organizational structure of airpower within the state. What type of organization, whether independent of other services or not, is less important than understanding what drove that state to pursue airpower in the first place. As such, the usefulness of this category as a measure of airpower adoption is limited. Excluding it does not take away from the central purpose of the paper. In any case, like the data on first aircraft acquisition dates, the dates of the first military aviation unit and the date of air force independence is often the same for a given country.

Considering the difficulties in collecting the data for these two categories it was somewhat surprising to find that data on military aviation units was more readily attainable and more consistently accurate from source to source. For clarity, I define a military aviation unit as a designated organizational component created within a state's military forces for the express purpose of operating and maintaining combat capable fixed-wing aircraft. These are, in essence, the military institutional structures created to support and employ military aircraft which may or may not be subordinated to another military service (usually the Army). Examples include the British Royal Flying Corps (1912), the French 'Aeronautique Militaire' (1909), and the Romanian 'Corpul Aerian Romana' (1910).

The military aviation unit is the best available proxy because it captures the hardware and software aspects of airpower. In nearly all cases a state's decision to acquire a military aircraft and establish a military aviation unit coincided.[63] This is only logical; military equipment requires trained personnel and a support apparatus in order to be used effectively. The military aviation unit, then, represents the software of organization which in turn operates the hardware of military aircraft. The military aviation unit also subsumes the concept of the independent air force. In the early 20th century most military aircraft operated under the aegis of army or navy forces. In the latter part of the century newly independent states usually arranged their militaries in the tri-service manner common among Western nations. In these cases the military aviation unit was independent at birth. For coding purposes I do not differentiate between independent air services and sub-service aviation units. Any permanent military organizational unit established post-independence for the purpose of operating and maintaining fixed-wing combat aviation is coded as a military aviation unit. For every year from 1909 to 2008 states were coded 1 if they possessed a military aviation unit and 0 if they did not.

Lastly, before moving to the analysis section it is helpful to highlight a few issues encountered in constructing the dataset. First, it is important to understand that cross national variation in aircraft and military organization record keeping and data availability is the primary challenge in this study. The lack of available information makes coverage difficult for the primary reference works on airpower including SIPRI's Arms Transfer Database, Jane's All the World's Aircraft, and IISS's Military Balance. As

[63] Latin America was a bit of an anomaly here. Several South American countries established aviation schools prior to actually purchasing aircraft for military service. These schools were staffed by European aviators and used leased European equipment.

a result, many of these publications simply exclude those countries for which reliable data is unavailable.

In order to cope with data inconsistencies I used a method of triangulation among the major reference sources. For each state in the dataset I attempted to confirm the published information from at least two additional sources. If there were discrepancies between these sources I sought out a third, fourth, or fifth when possible, in an attempt to adjudicate between the two. In those cases where multiple sources failed to align I established a hierarchy of sources based on the reputation of the publication and the extensiveness of its use in the field (Table 3). Though not ideal this method is, I believe, the most systematic approach to collecting and organizing this particularly dataset. Finally, in those rare cases where no source contained reliable data the state was excluded from the dataset.

Hierarchy of Data Sources	
1	Correlates of War State Membership Dataset
2	Stockholm International Peace Research Institute Arms Transfer Database 2011
3	International Institute for Strategic Studies Military Balance 2011
4	Jane's All the World's Aircraft 2011-12
5	Forecast International Defense Industry Database
6	David Wragg's *World Air Power Guide* (2010)
7	Newdick and Cooper *Modern Military Airpower 1990-Present* (2010)
8	Dutch Aviation Society *Scramble* Military Aircraft Database (2009)
9	Individual Country Air Service Websites

Table 3: Data Sources for System Membership and Military Airpower

Even where data was plentiful several obstacles had to be overcome to establish a viable dataset. Most of these obstacles represent coding decisions that require refinement of the core conceptual definitions. For instance, one common observation is that military aircraft were often delivered to colonies and dependent states prior to the date of these states' independence. In many instances, these states established formal military aviation units under the guidance of their colonial masters. Case in point, the Australian Flying Corps, while nominally under British rule, participated as a separate and distinct unit in WWI (Molkentin 2010). Australia did not, however, become politically independent until 1920.

This is problematic for my research question. I am trying to establish patterns in airpower diffusion at the national level. This assumes that states, or more accurately political leaders, consciously decide to establish aerial military forces for an explicit purpose. But if a colonial power imposes this military organization upon a colony the recipient state may have little or no say in its acquisition decision. To account for this I decided against using "first" dates that occurred while the state was under foreign control. Instead, I focus solely on those first dates that occurred after the state gained political independence regardless of its colonial legacy. In the Australia example, for instance, the airpower adoption year is coded as 1920.

III. Broad Trends in Airpower Diffusion during the 20th Century

The process of airpower diffusion was profoundly affected by the dramatic evolution of the international system in the 20th century. In the one hundred years from airpower's emergence to its most recent adoption the global political environment changed in two important ways. The most important change was the increase in the total number of states in the system. According to the COW System Membership dataset, there were 45 distinct political entities in existence at innovation emergence in 1909. In 2008 there were 194. This fourfold increase in the number of states represents a fourfold increase in the number of potential airpower adopters.

Figure 2 shows the growth in the number of states over time. From 1909 to 1917, despite high political tension and war in Europe, there was almost no change in the total number of states. In 1909 there were 45 independent states in existence. In 1917 there were 44 – the one state decline being the result of the American occupation of the Dominican Republic in 1916. With the end of WWI and the Versailles Treaty several new political entities emerged. Throughout the 1920's and 30's there was slow but steady growth. At the start of WWII the international system had grown to some 65 countries. The six years of world war that followed saw the brief disappearance of several states to German and Japanese occupation. At one point (1943) 14 states had lost their independence bringing the total number of states down to 52.

The post-war period brought the reemergence of these lost states along with a massive two wave expansion in system membership. This expansion came as the result of the major European powers casting off their colonial dependencies. Facilitated by the United Nations, the process of decolonization led to a rapid increase in the number of new states in Sub-Saharan Africa, the Middle East, and Southeast Asia (Gifford and Louis 1988). The first wave, from 1945 to 1959, saw the system grow from 64 to 89 states, a 39% increase. The following year (1960) was the most active of the decolonization period as 18 new states were created. This was followed by nearly two decades of rapid growth before tapering off in the early 1980s. From 1959 to 1980 the international system grew from 89 states to 156 states, a 75% increase. The final push for expansion came in the immediate post-Cold War period. In 1989, the international system was comprised of 161 independent states. Within five years it had grown to 187. Over the next decade and a half slow but steady growth brought the total number of states to 194.

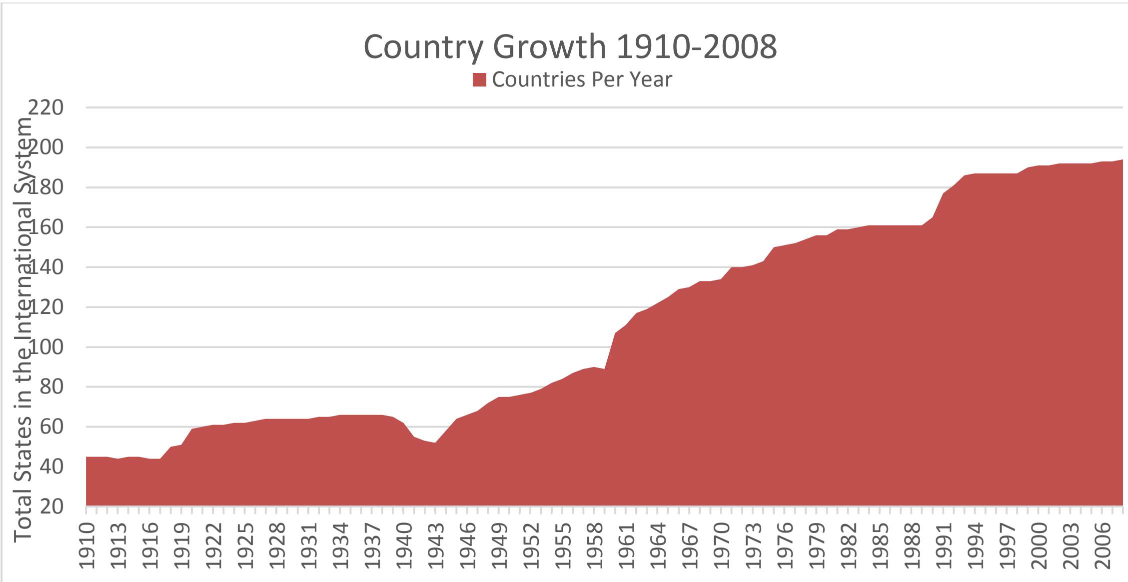

Figure 2: International System Membership by Year

Beyond the simple number of independent political entities, the qualitative characteristics of states changed dramatically. The evolution of the international system from early to late 20th century involved a structural shift from a few, large states with vast territorial holdings to many small and mid-sized states with few extraterritorial dependencies. Again the majority of these new states were carved out of the territorial holdings of the major colonial powers. Each newly independent former colony represented some piece of land and wealth transferred from the former colonial master to the new nation's political leaders. Thus, the expansion of new, independent states coincided with the decline of the major European colonial powers. Wealth that had been concentrated in Western Europe diffused to new areas around the globe. The extent of this transfer was limited, however, by the dependency of newly independent states on their colonial patrons for political support and economic assistance (Ahiakpor 1985).

Turning from general political trends to airpower specifically, Figure 3 provides a broad look at the extent of airpower diffusion from 1909 to 2008. As a whole, the pattern of airpower diffusion as measured by the number of states with designated military aviation units largely follows the trend in the expansion of states in the international system. During periods of system expansion the number of airpower adopting states expands as well. During the brief period of contraction during WWII the number of airpower states contracts accordingly. This period of contraction is, of course, a result of several airpower states being conquered by invading armies rather than an explicit political decision to abandon airpower. Once the war ended and the conquered regained their sovereignty aerial military forces were quickly re-established.

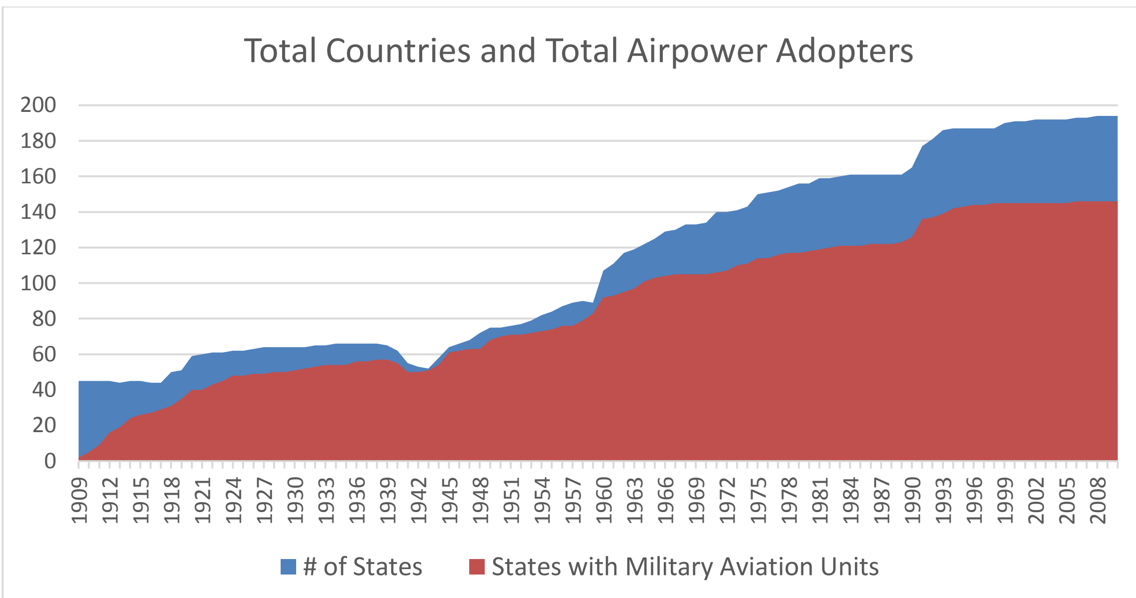

Figure 3: International System Membership and States with Military Aviation Units

Though airpower grew consistently throughout the 20th century there were periods in which the relative ubiquity of airpower fluctuated. The most obvious example is from 1909 to 1917. In the earliest days of airpower many political and military leaders were skeptical of aerial warfare and the efficiency of allocating scarce defense resources toward aviation. Despite this skepticism, the gap between the number of total states and the number of airpower states closed rapidly. From around 1917 to the start of WWII the growth in the number of airpower states tapered off some but continued steadily upward (Figure 4). In 1917 roughly 66% of states had established military aviation units. By 1939 that number had risen to 88%. Around that time airpower closely approached the point of full system adoption. The high water mark came in the middle of WWII at the time when, not coincidently, the number of the total states in the system was at its lowest. At this point in 1943, 98% of all states possessed some aerial military forces.

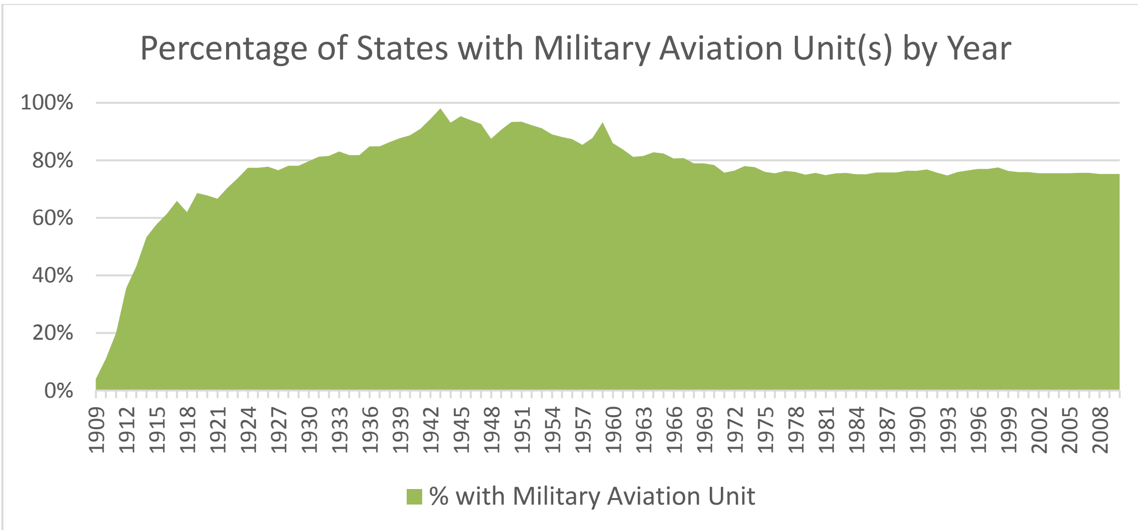

Figure 4: Proportion of Total Number of States that are Airpower Adopters

The end of WWII and the era of decolonization and national self-determination that followed reversed the previous trend in system-wide airpower adoption. From 1909 to 1943 airpower states as a percentage of total states continually increased, albeit at varying rates. From 1943 onward this percentage decreased steadily. From the 98% point in 1943, the percentage of airpower states fell to 85% in 1957 and then to 76% in 1971. As the total pool of states expanded the percentage of airpower states among them fell. This continued until around 1971. From that year onward the percentage of airpower states remained relatively constant. Despite the shifting nature of the international political and security environment, the system-wide adoption percentage has changed little. In the absence of some major technological or political event it appears that this rate, around 76%, will persist for some time. This is not to say that airpower has stopped expanding. In each of the past four decades the absolute number of airpower states has increased. However, this increase has only kept pace with the broader increase in the total number of states. So while the percentage of the system that has adopted airpower has stagnated, the number of new individual airpower adopters continues to grow.

Why has airpower diffusion stagnated? The answer is not entirely clear. One simple reason for the relatively consistent airpower adoption percentage in the latter 20th century comes from the statistical properties of the sample. In the early 20th century when the total number of states was small, a single state's decision to adopt meant at least a 2% increase in total adoption percentage. As the number of states grew the impact of each state on the overall percentage decreased. This accounts for some of the stability in the year to year variance. This does not, however, explain why over several years, decades even, the percentage stayed near constant. Instead, this infers that since around 1971 roughly half of newly independent states have become airpower adopters while half have not.

What accounts for this? One explanation could be that the technological sophistication of modern aircraft and the personnel who fly and maintain them have made airpower too expensive for newer, poorer states (See Kaldor 1981). Where new states may want to acquire airpower, they simply cannot due to their financial circumstances. Similarly, the technical skills required to operate modern aircraft and their associated weapon systems may be beyond the capacity of newly emergent conscript armies. Operating an air force requires a great deal of professional training. Most newly independent states lack the heavily institutionalized military training systems and professional military ethos found in the West (Huntington 1957).

An alternative explanation may be that the perceived efficacy of airpower is waning. After the very public failure of American airpower in Vietnam and Soviet airpower in Afghanistan, newer more impressionable states may have learned the lesson that there are, in fact, limits to conventional airpower, particularly in counterinsurgency conflicts (Clodfelter 2006; Pape 1996; Nelson 1985). Acknowledging the limits of airpower reduces the impetus for acquiring aircraft, building facilities, and training pilots. Put simply, states will not devote resources to airpower if they do not think airpower will help them defeat their enemies.

Finally, looking broadly at the global political environment we see that the stagnation point coincides roughly with the beginning of detente and rapprochement between the two super powers. Up until the 1970s the United States and Soviet Union were engaged in a fierce global competition for allies among newly emerging states. A major tool for garnering support was foreign economic and military aid to newly independent nations. Often this aid took the form of financing and, at times, the direct transfer of U.S. and Soviet military equipment, including aircraft (Sanjian 1999; Kinsella 1994). As the relationship between the powers warmed, the incentive to supply newly emerging states with weapons weakened. The end of the Cold War made the case for arms assistance even more tenuous. Even so, the defense industries of the major arms producers, namely the United States, France, Britain, and Russia, continue to market their wares around the world (Holtom et al. 2013). The vast majority of non-airpower states have access to the major arms manufacturers. Again, this leads one to wonder why airpower has not expanded further. This question warrants additional study in future research.

IV. Airpower Diffusion in the Early 20th Century

This section focuses on testing the hypotheses presented in Chapter 2 on airpower adoption in the pre-WWI period. The population under investigation includes only those states in existence in 1909 (Group A states). The purpose is to identify the key determinants of airpower adoption during this brief period of airpower infancy. The findings from this section can then be compared against those collected from the late airpower adoption period to identify temporal differences in the relative effect of each causal factor on the diffusion of airpower.

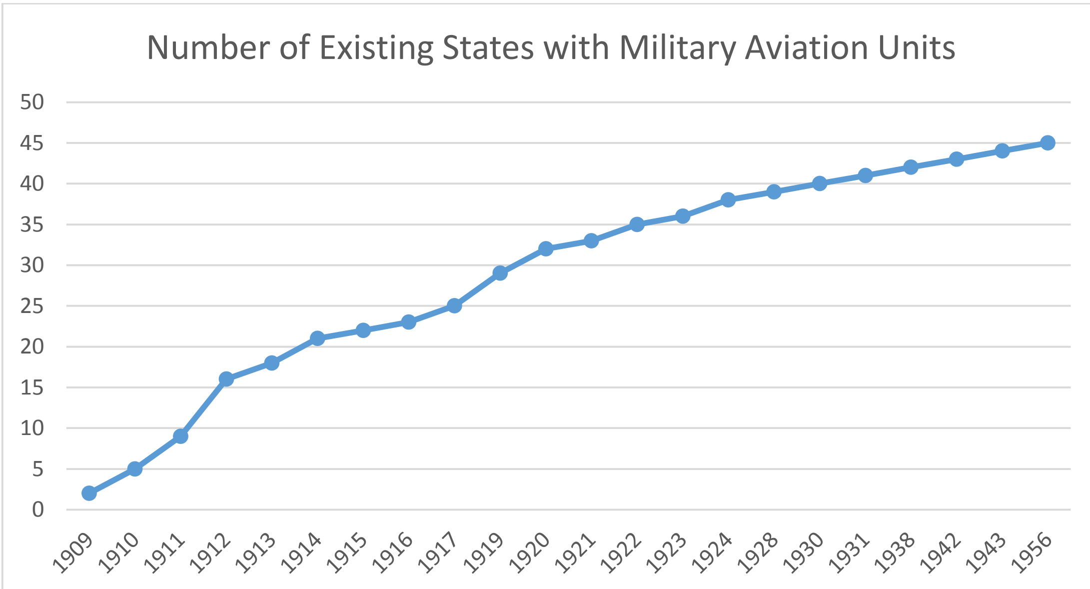

Figure 5: Cumulative Airpower Adopters over Time

The first thing to notice is that the pace and rate of airpower adoption conforms somewhat imperfectly to Rogers's S-curve. The early period shows a steadily increasing slope followed by a rapid acceleration in the pace of adoption. However, around the 40% mark adoption slows markedly. Rogers's model assumes that this deceleration should occur around the time two thirds of the available units have adopted the innovation. With the sample distribution this should theoretically occur after 1919. We do see that after this point the number of adopters per year decreases as predicted. But there is no statistical explanation for the low adopter counts from 1913 to 1917. There is, of course, a practical explanation – the outbreak of WWI. This massive disruption in the international security environment seems to have played a role in delaying the adoption process.

In any case, one finds that this four year period of low adoption distorts what would usually be a normal distribution. Figure 6 provides a clearer picture. The graph shows a rise on the left and a fall on the right but also contains a sag in the middle where the top of the bell curve should be. Notice also the lengthy tail on the right hand side of the graph. Consistent with Rogers's findings, the last phase of adoption draws on the longest as the laggards' lengthy decision making process and/or lack of resources pushes the point of full adoption well into the future (Rogers 1999, 265).

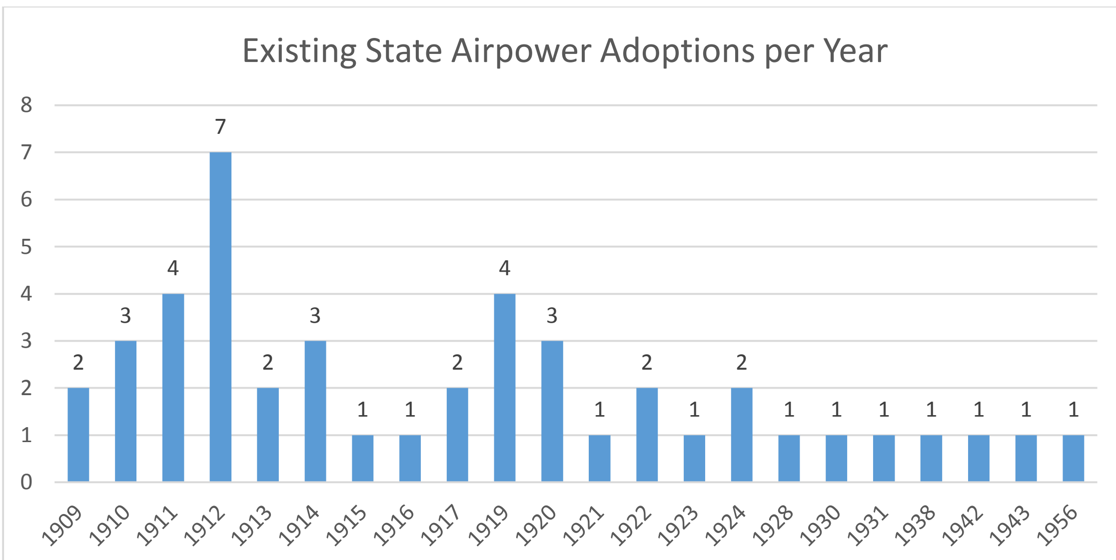

Figure 6: Airpower Adoptions over Time

Despite that lack of a normal distribution Rogers's adoption categories can still be applied to the population. Using successive standard deviations from the mean, we find that the "innovators" include the United States and France (4.4%). Next are the "early adopters" representing the first 13.5% of potential adopters. This group includes Austria-Hungary, Germany, and Romania. The next category is the "early majority". This includes those states that adopted prior to 1916. Together these three categories make up the first half of the total pool of states. The "late majority" group lies one standard deviation to the right of the mean and includes the adopters between 1916 and 1924. The "laggards" make up the final 16% of the total and include every adopter from 1925 to 1956.

This process highlights several key trends. First, there is a strong regional component to the diffusion process. At airpower emergence in 1909 the majority of independent states were concentrated in Europe and Latin America. Among these two regions, Europe was the most active in the early adoption phase. Some 17 of the first 22 airpower adopters were European states. Nearly all of the states in the first three adoption categories - innovators, early adopters, and early majority – were European. By 1917 every European state in existence at the time had adopted. The diffusion process then shifted to Latin America. In 1914 Chile became the first South American state to establish a permanent aerial military arm and was followed closely by Uruguay and Cuba in 1917. The immediate post-war period saw a burst in airpower adoption in the region as Argentina, Guatemala, Honduras, and others from South and Central America followed suit. Outside of Europe and Latin America the only other countries were the United States (innovator), Japan and Thailand (early majority), China and Iran (late majority), and Ethiopia and Morocco (laggards).

Second, the order in which states adopted airpower correlates with multiple state characteristics associated with the hypotheses discussed in the previous chapter. Using data from the Correlates of War project, namely the National Military Capabilities dataset, the Diplomatic Exchange dataset, the Bilateral Trade dataset, and the Polity IV dataset, we find that the airpower adoption rank correlates with CINC score rank, total population rank, diplomatic exchanges[64] rank, and IGO membership rank. Table 4

[64] Diplomatic exchange is calculated by summing up the total number of diplomatic postings a state had (at the charge d'affaires, minister, or ambassador level) for each year. For any given year, if a state had representation in another state at any of those levels it was assigned a value of one point. The points are totaled for the state in that year.

presents a list of all 44 states along with their ranks in each of these categories from first (1) to last (44) as of 1909.[65] The "adoption rank" column lists the states in the order in which they adopted airpower starting with the United States and France (1) and ending with Morocco (22). Note that states adopting in the same year share the same rank, the next year being given the following number in sequence. The next four columns represent the rank of each of the states on each of the four independent variables with 1 being the highest and 44 the lowest. One state, Panama, was dropped from the analysis as there was no data available for any of the above variables.

[65] Data was rank transformed in order to standardize the distant between each state on a 1 to 44 scale. This allowed for easier comparison across categories with different units of measurement.

STATE NAME	AIRPOWER ADOPTION RANK	CINC SCORE RANK	POPULATION RANK	DIPLOMATIC EXCHANGES RANK	IGO MEMBERHIP RANK
UNITED STATES	1	1	3	2	8
FRANCE	1	6	8	2	1
GERMANY	2	3	4	1	4
AUSTRIA-HUNGARY	2	7	5	6	3
ROMANIA	2	18	18	21	10
JAPAN	3	8	6	12	13
ITALY	3	9	9	1	2
SPAIN	3	11	12	4	7
BELGIUM	3	12	17	3	5
RUSSIA	4	4	2	7	6
UNITED KINGDOM	4	5	7	1	2
SWEDEN	4	14	22	13	7
BULGARIA	4	25	25	24	15
DENMARK	4	26	30	16	9
YUGOSLAVIA	4	28	29	19	14
GREECE	4	29	31	20	14
NETHERLANDS	5	15	20	5	4
THAILAND	5	23	16	19	21
TURKEY	6	10	10	18	17
CHILE	6	21	28	10	14
SWITZERLAND	6	27	27	16	7
NORWAY	7	24	33	15	14
URUGUAY	8	32	38	14	16
PORTUGAL	9	20	21	11	11
CUBA	9	34	34	27	20
CHINA	10	2	1	18	22
ARGENTINA	10	17	19	10	13
GUATEMALA	10	37	39	19	19
HONDURAS	10	44	43	23	21
PERU	11	33	26	11	18
VENEZUELA	11	35	32	22	22
ECUADOR	11	38	37	21	20
COLOMBIA	12	30	23	16	20
BRAZIL	13	13	11	8	12
IRAN	13	22	14	18	21
EL SALVADOR	14	40	40	21	20
MEXICO	15	19	13	9	15
BOLIVIA	15	39	35	17	21
PARAGUAY	16	42	42	14	21
ETHIOPIA	17	16	15	26	23
NICARAGUA	19	41	44	21	18
DOMINICAN REPUBLIC	20	43	41	24	22
HAITI	21	36	36	25	21
MOROCCO	22	31	24	N/A	24

Table 4: List of States by Adoption Rank and State Power Variables

Table 4 shows that, in general, the higher the airpower adoption rank (high being near 1), the higher a country's rank in all four other columns. For example, of the first 16 airpower adopters there are 8 states in the top ten in all four categories. Only China, with a high rank on total population (1), has a relatively low airpower adoption rank (10). Of the earliest airpower adopters, the "innovators" and "early adopters" categories, 4 out of the 5 are in the top 10 in total population. Within this group Romania is a bit of an outlier. The Romanian Army established its first military aviation unit, the 'Corpul Aerian Romana', in 1910. This represents a relatively early adoption for what was, in essence, a middling military power at the time.

Next, each of the explanatory variables was placed into a Cox proportional-hazard model to assess their relative effect on time to adoption. This form of duration model is widely used in domestic American politics literature and is designed to determine the impact of each covariate on the amount of time until an event takes place – in this case the time to airpower adoption. The model then determines the risk of airpower adoption (the dependent variable) at different values of the independent variables. The variables used in the model are listed in Table 5 below.

	Variable Name	Description and Coding Procedures	Data Source
H_3	MIDs	The 5 year moving average of militarized interstate disputes; continuous variable	Militarized Interstate Disputes v4.01
H_4	Enduring Rivalry	3 MIDs with the same state over a 15 year period; dichotomous variable	Klein, Goertz, and Diehl 2006
H_5	CINC Score	CINC score assigned for each state; log transformed continuous variable	National Material Capabilities v4.0
H_6	Total Population	Total state population; log transformed continuous variable	National Material Capabilities v4.0
H_7	Alliances	Alliance with major airpower state (France or Germany); dichotomous variable	Formal Alliances (v4.1)
H_8	Democracy	State with polity score of 7 or higher; dichotomous variable	Polity IV Project
H_9	IGO Membership	Total number of international governmental organizations state is a member of; continuous variable	International Governmental Organization (IGO) Data v2.3
H_{10}	Diplomatic Exchanges	Total number of other countries in which state has diplomatic representation; continuous variable	Diplomatic Exchange v2006.1

Table 5: List of Measures for Independent Variables

The hazard model produces a hazard ratio for each independent variable. The hazard ratio can be interpreted as the percentage increase in the likelihood of airpower adoption for a one unit increase in each independent variable. For example, a hazard ratio of 1 means that changes in that particular independent variable have no effect on the risk of airpower adoption. A hazard ratio greater than 1 means that the risk of airpower adoption increases with increases in that particular variable. High hazard ratios mean earlier airpower adoption. Similarly, a hazard ratio less than 1 indicates that the variable decreases the risk of airpower adoption and is therefore associated with later airpower adoption. The statistical output of the duration model is presented in Table 6. Additionally, survival curves for the full model and the statistically significant independent variables are represented graphically in Figures 7, 8, and 9.

Survival Analysis of Airpower Diffusion			
	Hazard Ratio	Robust Standard Error	P-Value
MIDs Previous 5 Years	1.093	.135	.470
Enduring Rivalry	.920	.323	.812
CINC Score	2.117*	.794	.045
Population	.565	.214	.132
Alliances	1.529	1.317	.622
Democracy	.818	.449	.714
IGOs	1.163**	.053	.001
Diplomatic Exchanges	.947	.033	.124
N (states) = 43, N (state-years) = 356; Wald chi2(8) = 75.65; CINC and Population are logged			
*Notes: *p<.05, **p<.01*			

Table 6: Cox Proportional Hazard Model – State Variables on Time to Adoption

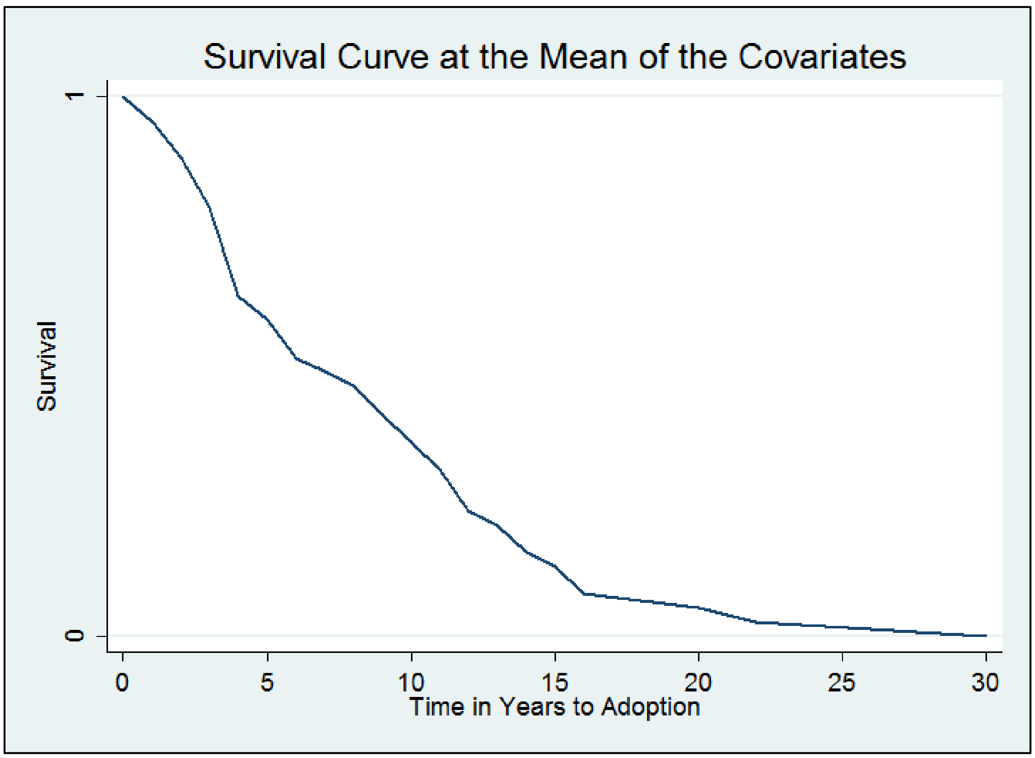

Figure 7: Survival Curve for the Full Model

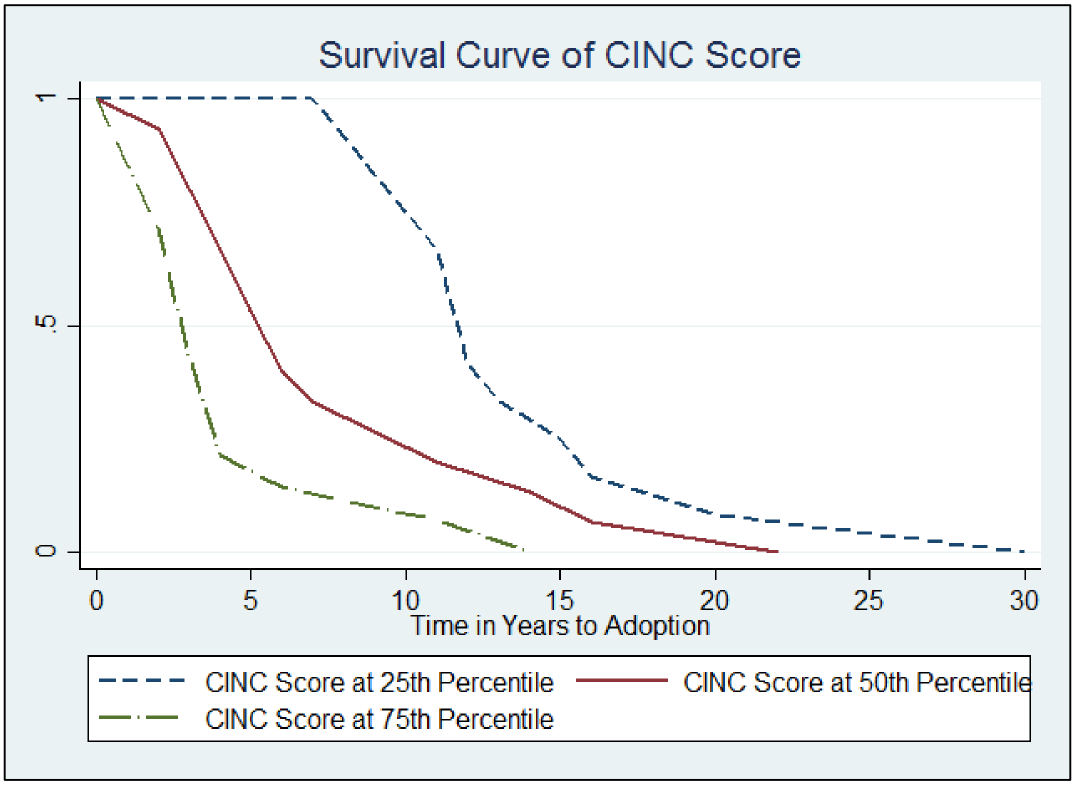

Figure 8: Survival Curve for CINC Scores at Quartiles

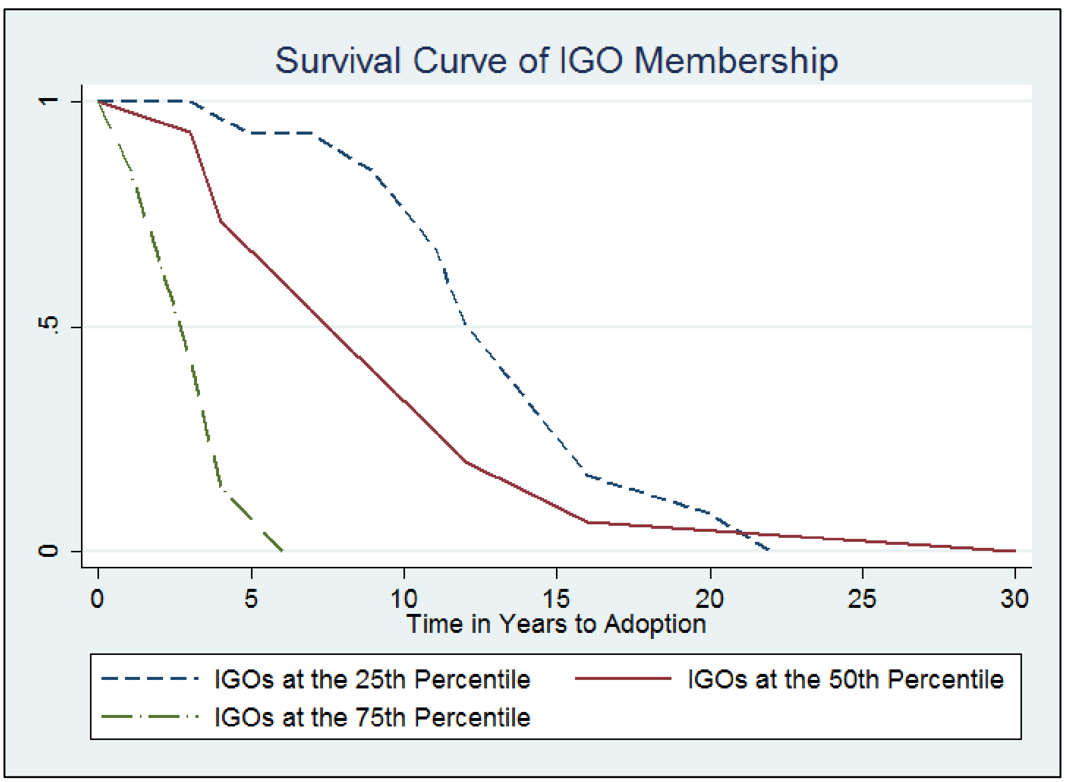

Figure 9: Survival Curve for IGOs at Quartiles

The hazard model reveals that two of the eight variables produce statistically significant results. The most substantive effect comes from CINC scores. CINC score has a hazard ratio of 2.117 and is statistically significant at the .05 level. This means that the risk of airpower adoption rises 112% with each one unit increase in CINC score. IGO membership has a similarly positive effect. A hazard ratio of 1.163 indicates that for each additional IGO a state belonged to its risk of airpower adoption rose by 16%. This means that high CINC scores and greater IGO membership are associated with earlier airpower adoption.

The survival curves illustrate the effect of each variable graphically. Figure 7 shows the survival curve of the full model at the means of the covariates. Notice the rapid descent of the curve, indicating rapid airpower adoption, until about the 6 year mark. After this point the adoption rate slowed but remained steady until about the 16 year mark. The impact of high, medium, and low values of each of the independent variables can be seen in Figures 8 and 9. For reference, low values refer to 25th percentile mark, medium values the 50th percentile, and high values the 75th percentile on that particular variable.

Among the two significant independent variables there is some variation in how movement from low to high values shape the survival curve. On CINC scores, for instance, the effect of moving from medium to high is relatively small. The curves at both medium and high values take on a similar shape. The move from low to medium CINC score values shows a much greater degree of separation. It seems then that variation in time to adoption among states in the upper half of CINC score was rather mild while variation in the lower half had a more pronounced effect on time to adoption. This shows that the relative influence of CINC score on airpower adoption was not uniform across the entire population range.

IGO membership displays the opposite pattern. Notice here that the low and medium level survivor curves are more closely aligned while the high level IGO membership curve is significantly more vertical. This indicates that high levels of IGO membership were associated with rapid military airpower adoption. Case in point, the latest airpower adopting state among the top 25% in IGO membership adopted only 6 years in. Contrast this with the medium value group which contains the latest airpower adopting state at 30 years and the low value group whose latest adoption came at the 23 year mark.

V. Findings and Conclusions

The notion that military airpower will diffuse across all states in the international system is not supported by the evidence, though this finding requires qualification (H_1). Looking at the whole of the 20th century it is clear that airpower underwent a rapid early adoption period followed by slow but steady growth before actually receding some in the 1950s and 1960s (See Figure 3). Around 1970 the proportion of the international system with fixed-wing military aviation units reached a steady state, and as a result, has changed little in the last 40 years. Since then it appears that airpower diffusion has proceeded at a pace roughly equivalent to that of new state formation. This means that airpower has not diffused to 100% of the system but rather about 75%. Of course, this assertion assumes that the "system of interest" is, in fact, the entire collection of states in existence today. If, however, the "system of interest" refers to the collection of states in existence at innovation emergence (1909) then the hypothesis is supported by the evidence. Though the time to adoption varied among them, all independent states as of 1909 did eventually establish fixed-wing military aviation units. In this context, then, the assertion that airpower will diffuse across the entirety of the international system is actually correct.

The proposition that airpower diffuses quicker among states within the same geographic region is supported by the evidence (H_2). Aside from the initial American adoption, nearly all the subsequent airpower adopters over the next five years were European states. Case in point, of the first 22 adopters, 17 were European countries. By 1917 all European states had adopted airpower. The regional pattern then repeated itself in South America where Chile led the charge. It was quickly followed by its regional competitors.

The notion that a history of disputes or enduring rivalries increases airpower adoption rate is not support by the evidence (H_3) (H_4). In the hazard model neither of the two variables reach statistical significance. Interestingly, dropping one or the other or both from the model has little effect on the other variables. The same two variables remain statistically significant in the same direction. Building off of the evidence from last chapter, it seems that external threat did not play a role in the rate of airpower diffusion but rather only in the level of intensity with which states pursued airpower once they had established their first military aviation units.

A key determinant of early airpower adoption was national military power resources (i.e. CINC score). The evidence supports the notion that states with high military capabilities adopted airpower earlier (H_5). As one might expect, the countries with the greatest national military resources in 1909 were also the ones most willing to allocate funds to initial aircraft purchases. The visual correlation in the rank chart is confirmed by the output of the duration model. Indeed, with the highest hazard ratio among the significant variables it appears that CINC score had the largest substantive effect on airpower adoption rate.

The impact of population on airpower adoption is mixed (H_6). A cursory glance at the rank chart seems to indicate a positive relationship between the two variables. Of the

9 earlier airpower adopters, 6 of these states are in the top ten in population rank. But in the hazard model the coefficient on population fails to reach statistical significance. It seems that, in the presence of controls, population had little to no effect on airpower adoption decisions. Consequently, there is little evidence to support the notion that political leaders in sparsely populated states reacted to the innovation of airpower any different than leaders in heavily populated states.[66]

The notion that alliance patterns, or more specifically an alliance with one of the two major airpower states of day, influenced the diffusion military aviation is not supported (H_7). In the duration model the hazard ratio on alliances is positive but the finding does not come close to even the .1 level of statistical significance. Of course, the data in this chapter pertains only to initial airpower adoption and not to adoption intensity. It is certainly possible that adoption intensity i.e. the acquisition of large numbers of aircraft may in fact be related to alliances patterns.

The proposition that military airpower will diffuse more rapidly to democratic states is not supported by the evidence (H_8). In the hazard model the coefficient on democracy fails to reach the threshold of statistical significance. I suspect that the lack of statistical significance in any direction is due to the fact that in 1909 there were only 6 total democracies and therefore relatively little variation on this particular independent variable.

The notion that status concerns increase the speed with which states adopted airpower is supported by the evidence (H_9). In the duration model greater IGO membership is shown to reduce the time to airpower adoption. For a one unit increase in

[66] Note that China appears a major outlier on the adoption rank chart. The models was re-run to test the effect of omitting China from the dataset. This resulted in slight changes to the coefficients on population, though, ultimately it mattered little as the findings again failed to achieve statistical significance.

IGO membership the risk of airpower adoption increases by some 16%. Thus it appears that embedded states, those that were deeply involved in international organizations, were more apt to adopt airpower earlier. This confirms the findings from the previous chapter indicating that national pride and prestige were important elements in driving early airpower adoption.

There appears to be little association between diplomatic exchange and airpower adoption rate (H_{10}). In the hazard model the hazard ratio is less than one indicated that a large number of diplomatic exchanges may have actually lengthened the time to airpower adoption. This finding fails, however, to reach statistical significance at the .1 level. Instead, the general conclusion is that, among the entire population of the states in existence in 1909, the number of diplomatic communication channels did not produce a notable effect on the speed with which states adopted airpower.

Finally, the focus so far has been almost exclusively on the internal determinants of airpower adoption at the exclusion of any discussion on the cumulative effect of prior state adoption on subsequent state adoptions. The assumption here is that the airpower adoption pattern follows the shape of an S curve. In an earlier section we saw that, indeed, early airpower diffusion did follow a somewhat imperfect S curve. In an effort to clarify this point, a cumulativity variable was placed into the hazard model to assess the impact of the total number of prior state adoptions on time to adopt. The results show that prior adoptions have an effect on time to adopt that is statistically significant (.01 level) but substantially lower than CINC score in the original model (HR = 1.298). This means that, on average, each additional adoption increases the odds of subsequent adoption by nearly 30%. Notably the inclusion of this variable eliminates statistical significance on all other variables in the model.

The practical significance of this statistical finding is unclear. It only begs the question, were subsequent adoptions born out of a fear of inadequate airpower capabilities, or was it simply a matter of aviation technology availability? The duration model fails to enlighten us on this point. However, from the evidence presented in the previous chapter it seems likely that the fear of military inadequacy at least partially drove early European adoption patterns (especially the French-German rivalry). The Germans, in particular, were acutely aware of French interest in fixed-wing aviation and planned their own acquisitions in response to French military exercises and aircraft purchases (Morrow 1976). Later adoptions in areas where the security dilemma was less intense may, on the other hand, have been limited by aircraft availability. This would explain the rapid pace of European adoption followed by the lingering adoption period outside the region thereafter.

Chapter 5: The Proliferation of Military Airpower in the Late 20th Century

The purpose of this chapter is to explore the proliferation of military airpower in the late 20th century. The chapter is split into five sections. The first section provides a brief discussion of the major geopolitical and technological changes impacting the distribution of airpower in the post-WWII period. The second section describes the data collection and coding methods used to create an airpower diffusion dataset covering the late 20th century. The third section explores broad patterns in global and regional airpower diffusion from 1969-2013. The fourth section tests the hypotheses presented in Chapter 2. The final section draws conclusions from the evidence and compares the relative support for each of the competing airpower diffusion hypotheses.

I. A Changing Landscape – Airpower in the Late 20th Century

The process of airpower diffusion in the latter part of the 20th century was vastly different from that of the early 20th century. For one, the composition of the international system changed markedly from 1918 to 1945. The Second World War, in particular, dramatically altered the geopolitical landscape by giving rise to a new superpower dominated, bipolar system. The ascendance of the United States and the Soviet Union coincided with the decline of the traditional European powers and the dissolution of their overseas empires. The casting off of colonial possessions brought about the establishment of dozens of smaller, poorer members of the international system. A handful of these newly independent states quickly established impressive airpower capabilities.[67] Most, however, were left with aging, inferior military equipment and without the means to replace it. As such, the distribution of airpower capabilities around mid-century remained heavily skewed toward Europe and North America.

[67] Israel, the People's Republic of China, and Egypt are a few examples.

Second, whereas aircraft and aviation equipment flowed freely across international borders in the pre-WWI environment, in the latter 20th century military aviation technology became more tightly monitored and controlled by national governments. In retrospect, it is rather remarkable how cavalier European governments had been toward the export of military-related technologies as late as 1914. In that early period most governments had access to advanced aircraft models from the community of European aircraft manufacturers (Hallion 2003, 279-284). The Germans, Austro-Hungarians, and Turks could freely purchase French and British models while the French, Russians, and Italians had no difficulty acquiring various German and Austro-Hungarian designs. Potential enemy aircraft were usually not employed in any meaningful numbers but were evaluated to determine strengths, weaknesses, and potential for replication. By contrast, the Israeli capture of an Iraqi defector's Mig-21 in 1966 was seen as a major coup for the Western allies (Cohen 1993, 187-190). The aircraft was eventually transported to the United States where it underwent a rigorous technical evaluation.[68] The findings then influenced the aerial tactics and training of U.S. Air Force and Navy pilots (Lowery 2010).

Today, the acquisition of aviation assets is no longer a simple matter of economic exchange but rather a complex activity involving a mix of domestic and foreign political, commercial, and diplomatic relations. Most combat aircraft purchases are negotiated on a government to government basis and involve lengthy political negotiation on issues beyond unit price like technology transfer policies, maintenance and servicing support, and off-set agreements. Even transactions between governments and foreign commercial firms are usually subject to political oversight and approval (Wilson 2001). In most cases, the oversight process is designed to contain sensitive military technologies but it

[68] The technical evaluation was referred to as Operation Have Doughnut and involved 52 days of flight tests performed in early 1968.

can also be used to reward or punish recipient state behavior (Blanton 2005). The end result has been a trend toward the politicization of military arms sales, with military aircraft serving as a prime example.[69]

Third, the tightening of security controls coincided with major improvements in the availability and capability of aviation technology. The quantity of equipment available on the open market came from surplus stocks of aircraft left over after the war. Many of these were sold or distributed to states whose wartime contributions or political allegiances were rewarded by the major powers. For example, immediately following the Japanese surrender in August 1945, the United States unloaded several thousand fighters, bombers, and transports on nationalist Chinese troops battling Mao's Communist forces (Xu 2001, 197-199). The Soviet Union did likewise in Eastern Europe. The distribution of surplus materials to fledging third-world powers was viewed as a relatively inexpensive way of currying favor among the undecided in the intensifying Cold War environment (Kinsella 1994; Krause 1991).

More importantly, the qualitative improvements in aircraft lethality achieved in WWII were built upon by aeronautic pioneers in the decades that followed. Advances in propulsion, electronics, and weaponry fundamentally altered the definition, scope, and purpose of airpower. The massive improvements in firepower, range, and speed accompanying the jet age brought airpower on par with sea- and land-based power (Sherry 1989). Indeed, for a time, its monopoly on atomic weaponry allowed the newly independent United States Air Force to threaten preeminence over its sister services (Armacost 1969). Even in its conventional role, military aviation cemented itself as a core

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[69] One could argue that the post-Cold War period de-politicized international arms sales to a certain degree. True, the intense East-West rivalry has disappeared, though, the increasing public awareness and pressure on states to take responsibility for armaments end-use and the rise of off-set and work-share agreements has kept the political aspect alive and well. See Keller 1995.

mission area for industrialized nations seeking to protect their territory from foreign invasion. Combat aircraft were no longer an auxiliary to the existing branches of the armed forces but rather a fundamental component of national defense. The wartime maturation of aviation technology made this transition possible.

Finally, the rapid post-war diffusion of airpower capabilities increased the number of airpower demonstration opportunities in smaller, more confined operational environments. These limited conflicts provided valuable lessons on the nature of jet age air combat. The clash of American and Soviet technologies over Korea, Vietnam, and the Taiwan Straits highlighted divergent philosophies in aircraft design, unit organization, combat tactics, and personnel training. These difference became more evident in the Middle East where Israel's various clashes with its neighbors in the 60s and 70s re-emphasized the importance of personnel, planning, and tactics over quantitative superiority (Higham 2006). In the 1990s, the full potential of combined technological dominance and personnel proficiency was unveiled in American military engagements in Iraq, Bosnia, and Kosovo. The precision revolution put on display against the forces of Saddam Hussein and Slobodan Milosevic marked the most significant development in aviation since the invention of jet propulsion (Lambeth 2000). The transition to an all precision-guided airpower environment remains ongoing today and is only rivaled in potential impact by the rise of unmanned aerial vehicles (Van Creveld 2011; Deptula 2011).

II. Data Collection and Methodology

In order to identify the factors driving the proliferation of military airpower in the late 20th century, I compiled a new dataset on state characteristics and airpower capabilities from a variety of data sources. This dataset consists of several measures linked to the competing hypotheses in Chapter 2 and encompasses all of the states in the international system with sizable military forces.[70] This approach provides a comprehensive illustration of the distribution of airpower at select points in time along with longitudinal data illustrating the changes in international airpower capabilities over time. By using a quantitative, large-n approach, I am able to uncover broad trends in airpower diffusion, measure the relative causal strength of the competing hypotheses, eliminate case selection bias, and derive broadly generalizable conclusions.

Under ideal circumstances I would apply the duration model from the previous chapter to the late airpower adopter cohort. This would allow a direct comparison of the findings between both groups. However, there are two serious methodological issues that prevent me from doing so. The first is data integrity, specifically the unreliability of military aviation unit establishment dates for smaller, underdeveloped states. Even using the triangulation method described in the last chapter it is difficult to determine when military aviation units were established in many Sub-Saharan African and Southeast Asian countries. It is not uncommon to find conflicting sources or, more often, no clear source at all. Often the accounts differ by several years, if they give specific dates, and fail to specify whether these units operated fixed or rotary wing aircraft.

Despite these limitation the basic data on aviation unit adoption is presented in aggregate format in Figures 3 and 4 in the previous chapter. This method of presenting the data gives a broad overview of system diffusion trends in which precise data on individual adoptions is less crucial. Using this same data in a regression model strains credibility - the accuracy (or inaccuracy) of each observation has a far greater impact on the research findings. Any conclusions drawn from statistical analysis on the disaggregated late airpower adoption data would be highly questionable given the

[70] States deliberately omitted from the analysis were either sparsely populated (under 500,000 citizens) or did not possess military forces of any kind.

difficulties of coding/data replication. Thus, the display of aggregate diffusion patterns graphically is a matter of balancing ethical research concerns with the desire to produce relevant findings.

The second, and more important, methodological issue is the lack of variation on the dependent variable. In the early 20th century there was a good deal of lag between the moment of airpower emergence and national level adoption. In the later 20th century the lag between independence and adoption narrowed substantially. Case in point, the median time to adoption for late airpower adopters was 0 years. This means, of course, that the majority of newly established states created aviation units at the moment of independence, usually as part of establishing a national military force. The lack of variation exacerbates the data integrity issue. Since those states that did have a lag between independence and adoption make up a minority of the sample their importance in determining the hazard ratio is enhanced. Given that the vast majority of *these states* only lagged 3 years or less, the precision of measurement (which is admittedly poor) would be absolutely critical. Thus, the lack of variation on the dependent variable combined with the data integrity issue make it extremely difficult to apply the duration model to the late airpower adopter cohort. As such, I chose to focus the analysis in this chapter on airpower adoption intensity, an important measure of airpower diffusion with more accurate data available.

The most important data source used in creating the dataset was the International Institute for Strategic Studies' *Military Balance*. The *Military Balance* is an annually produced reference publication with information on the equipment, organization, and attributes of national military forces around the world. This data was used to construct the two dependent variables, namely (1) state combat capable aircraft inventories (CCA) and (2) state airpower score (APS). Data for the independent variables came primarily from the Correlates of War project, specifically the State System Membership dataset, National Material Capabilities dataset and the Diplomatic Exchanges dataset. Data on domestic political systems, specifically whether states were democratic or not in a given year, was pulled from the Polity IV project. Regional groupings are based on coding in the State System Membership data with one modification, the separation of Central and South Asia from East Asia and the Middle East.[71] All of the data was collected at four year intervals starting in 1969 and ending in 2013.[72] The measures for each of the independent variables are presented in Table 7.

	Variable Name	Description and Coding Procedures	Data Source
H_3	MIDs	The 5 year moving average of militarized interstate disputes; continuous variable	Militarized Interstate Disputes v4.01
H_4	Enduring Rivalry	3 MIDs with the same state over a 15 year period; dichotomous variable	Klein, Goertz, and Diehl 2006
H_5	CINC Score	CINC score assigned for each state; log transformed continuous variable	National Material Capabilities v4.0
H_6	Total Population	Total state population; log transformed continuous variable	National Material Capabilities v4.0
H_7	Alliances	Two separate variables, one for NATO and one for Warsaw Pact; dichotomous variables	Formal Alliances (v4.1)
H_8	Democracy	State with polity score of 7 or higher; dichotomous variable	Polity IV Project
H_9	IGO Membership	Total number of international governmental organizations state is a member of; continuous variable	International Governmental Organization (IGO) Data v2.3
H_{10}	Diplomatic Exchanges	Total number of other countries in which state has diplomatic representation; continuous variable	Diplomatic Exchange v2006.1

Table 7: Independent Variable List

[71] The separation of Central and South Asia is due to its unique political, cultural, ethnic, and social history that distinguishes it from East Asia and the Pacific and the Middle East and North Africa. The countries that make up this region were determined by the United States State Department classification of Central and South Asian states.
[72] Four year intervals were used for two reasons: (1) aircraft inventories do not change much on a year-to-year basis and thus the utility of annual data collection is limited, and (2) defense planning cycles are typically four to five years in duration. Witness the United States Quadrennial Defense Review.

While the independent variables are relatively straightforward, the dependent variables require further explanation. The Airpower Score (APS) is a single number attached to each state representing the level of combat airpower capability of that state in a given year. The numeric value represents the sum total of combat capable aircraft (CCA) in service weighted by aircraft generation.[73] Newer, more advanced aircraft are afforded greater weight and, as a result, produce a higher overall airpower score for countries with more modern aircraft inventories. States with older jet or propeller aircraft still receive points for possessing airpower assets but at a lower level. The purpose of using the APS is to account for qualitative variation in airpower capabilities between states. It ensures that airpower adoption intensity is focused on a state's desired overall airpower capabilities rather than simply the number of machines in one's aviation inventory. States with large numbers of older, cheaper, less capable aircraft are not as committed to airpower as those states with smaller numbers of newer, more expensive, and far more capable military aircraft.

The APS weighting system is conceptually simple in design but complex in execution. Since the early 1960s, jet fighter and attack aircraft have been organized into generations. The number of generations and exact specification of the characteristics that comprise each generation have been the subject of considerable debate (See Hallion 1990; Hebert 2008; Tirpak 2009). After evaluating the competing classification systems, I decided to rely on the system used by Thomas Zarzecki in this work on the diffusion of weapons systems in the mid-20th century (2002). Zarzecki's aircraft generation classification criteria are well-laid out in a straightforward manner with most aircraft models appropriately classified in the narrative and accompanying appendices.

[73] Total combat capable aircraft inventories include fixed-wing aircraft capable of delivering ordnance assigned to any branch of military service for a particular state including, for instance, the Air Force, Navy, Marine Corps, and Air Defense branches.

According to Zarzecki, there have been five generations of jet propelled aircraft since WWII. The first generation is composed of aircraft developed immediately after the war. These aircraft are characterized by swept-wing designs, unguided armaments (i.e. guns or cannon), and high sub-sonic speeds. Examples include the F-80, F-86, and the Mig-15. The second generation includes more aerodynamic, supersonic aircraft like the American "century series" models (F-105, F-104, F-106), the Soviet Mig-19, and the French 'Super Mystere'. Third generation aircraft are those designed and fielded in the 1960s and are notable for their more sophisticated on-board radar systems and the conversion to air-to-air missiles as their primary (and sometimes only) form of armament. The F-4 Phantom and the Mig-21 'Fishbed' are prominent examples. Fourth generation aircraft are the most common models seen in service today. These aircraft are characterized by improved maneuverability, multi-role capability, and the ability to incorporate precision guided munitions (PGMs). This class includes the American 'teen series' (F-14, F-15, F-16, F-18), the Soviet/Russian Mig-29 and Su-27, the European multi-national Tornado, and the Chinese J-10. The fifth generation is by far the smallest class and includes, as of yet, only aircraft fielded by the United States Air Force. The chief attribute of fifth generation aircraft is the incorporation of radar evading stealth technology. While Russia and China have fifth generation aircraft in development, at the moment, the only aircraft of this class to have seen service are the F-22, B-2, and the now retired F-117.[74]

Once the aircraft were classified by generation they were weighted on a progressive scale. Propeller-driven aircraft were assigned one point. First generation jets were assigned two points, second generation three points, third generation four points,

[74] So-called "4th generation plus" aircraft like the Eurofighter Typhoon, Su-35, and JAS-39 Gripen constitute high-end variants of 4th generation aircraft but fail to exhibit the stealth characteristics emblematic of 5th generation aircraft. The 4++ generation designation is mainly a marketing technique for improving overseas sales. See GAO 2011.

and so on. The points were then totaled for each state in each year. The total score per state, per year is a single observed value of the APS variable. The weighting system is intuitively simple but intentionally so. The more complex the calculation becomes by, for instance, assigning weights by model instead of aircraft class, or by using sophisticated equations to generate arbitrary point values, the less accessible the data becomes and the more difficult the interpretation of the statistical results. As it is, the simple scoring system aids the reliability of the study.

Second, the weighting system assigns progressively lower advantage to aircraft of each generation. This mirrors reality. For example, the shift from a high performance propeller aircraft like the American P-51 to a first generation jet like the Mig-15 results in a 100% APS increase (from 1 to 2 points). This is, in essence, a doubling of airpower capability. In the real world, air combat between these two types would be wholly one sided, the Mig-15 being far superior to the P-51 in nearly all areas including speed, acceleration, rate of climb, etc. By contrast, the shift from a third to fourth generation aircraft represents only a 25% increase in airpower capability (from 4 to 5 points). In reality, the performance premium of an aircraft like an F-15 over an F-4 is relatively low. While an air-to-air engagement between the two would favor the newer model, it would not be abnormal for the F-4 to achieve limited successes. The declining marginal improvement in aircraft performance is evident in the lengthening period of generational overlap in the late 20th century. While most propeller-driven fighters were replaced within a decade by first generation jet aircraft, many third generation models remain in service today some forty years after the introduction of fourth generation types. Case in point, at the moment no state has plans to completely replace their fourth generation aircraft with fifth generation models.[75]

As with any dataset there were technical and conceptual issues that had to be addressed in collecting, coding, and analyzing the information. Most of these issues come from changes in the manner in which IISS published its *Military Balance* data over time. In the early years, IISS only included countries with large, developed militaries, mostly in Europe, the Middle East, and East Asia. In addition, aircraft inventories were reported by total number of squadrons, rather than individual aircraft counts. At times these squadrons were of mixed aircraft types spanning multiple generations. Sometimes reconnaissance and training units were included as well. In order to account for these issues, I used average squadron sizes to calculate aircraft counts, divided mixed squadrons equally by the types listed, and included only reconnaissance and training aircraft that were explicitly marked as combat capable or quickly convertible.[76]

The more important issues are conceptual. For one, weighting airpower capabilities by generation assumes that aircraft within each generation are roughly equivalent. In reality, there is substantial variation between aircraft types within each generation based on their intended roles, missions, upgrade histories, and countries of

[75] The United States is the most obvious candidate and yet defense planners have made it clear that there are no plans to completely replace the F-15 in the air superiority role. Instead, the F-22 has been limited to 187 aircraft to act as a "silver bullet" force in case of large scale conflict. See Lee Ferran, "The $77 Billion Fighter Jets That Have Never Gone to War," *ABC News* (8 April 2011). Accessible at: http://abcnews.go.com/Blotter/77-billion-raptor-22-fighter-jets-war/story?id=13322450

[76] "Quickly convertible" aircraft are those designated as Operational Conversion Unit (OCU) aircraft. This British-originated organizational structure (subsequently adopted throughout the Commonwealth) designates aircraft set aside for training pilots on new aircraft types. OCU aircraft are usually not equipped with specific training features but are instead pulled from frontline service for a period of time. As such, they can be easily transitioned back into combat service if the need arises. This is consistent with the coding practices in the *Military Balance* series.

origin.[77] Second, using aircraft counts ignores the importance of serviceability, a major determinant of airpower capability. This is a particularly important problem in poorer, third-world countries lacking professionalized militaries. The advantages of large aviation inventories are lost altogether if none of these weapons can be brought to bear against the enemy.[78] Finally, and most importantly, the quantitative approach fails to account for airpower employment methods, training, and personnel quality. These "software" aspects are extremely important in aerial operations and are, perhaps, equal or greater in importance to airpower capability than the aircraft themselves.

Despite all of these issues, the benefits of this approach far outweigh the costs. First, none of the technical limitations of the IISS data are critical, all of them were mitigated by the steps discussed above. Second, the system of generation-based coding is, again, intentionally simplistic. Attempts to weigh aircraft by other measures (roles, manufacturers, technical characteristics) are fraught with coding issues that equal or exceed those used here. For instance, establishing a heuristic mechanism for calculating the equivalent value of American and Soviet aircraft is complicated by the fact that each aircraft model excels in different areas. This means that each model would have a different value depending on the model against which it was matched. Even then, establishing distinct values would be purely conjecture based on technical characteristics and analyst impressions.[79] In the end, this would produce an analysis that would, at first

[77] The glaring example being the qualitative difference between American and Soviet fighter aircraft. These differences stemmed from technological and doctrinal decisions. While the United States focused on producing the highest quality fighters possible, the Soviet Union was content with fielding large numbers of simply adequate aircraft. The Soviet emphasis on quantitative superiority meant that many, if not most, Soviet aircraft were out-classed by their American contemporaries.

[78] One could make the argument that having large reserves of unserviceable aircraft actively weakens one's military capabilities. Not only do the aircraft and support facilities require substantial initial investments, but the manpower diverted to operate and maintain these facilities could otherwise be devoted to land or naval forces.

[79] The value of each aircraft type would also vary based on the type of evaluation model used. Different assumptions in "one-yields-one", "one-on-one", and "one-against-all" models would produce different results and, in the end, only complicate matters further (See Lebovic 1996).

glance, appear more substantive but would ultimately rest on a bed of shaky assumptions scarcely more valid that those proposed here.

Finally, the issue of serviceability is at least partially accounted for with the generational approach. Newer generations of aircraft represent more recently acquired aircraft. These aircraft have fewer flying hours and, subsequently, less wear and tear. Naturally, then, one would assume that newer aircraft have higher serviceability rates. Their higher airpower scores are therefore representative of increased capability and assumed increases in serviceability.

The issue of airpower "software" is largely unavoidable in a large-n quantitative study such as this. Establishing with any degree of validity relative state capabilities in doctrine, training, and personnel is difficult, nay impossible. Having acknowledged this limitation, it is important to highlight the advantages of this approach. First, relying on a single data source for all states in all years covered ensures the comparability of data cross-sectionally and longitudinally. There are no issues with varying coding rules, data collection methods, or inter-coder reliability. Second, the data structure allows for the disaggregation of non-combat from combat aircraft types thereby allowing the analysis to focus on airpower as a direct means of making war rather than as a supporting element to the other services. Third, the generational classification system accounts for qualitative variation between countries while remaining grounded in quantitative measures. Fourth, and most importantly, the data allows for the tracking of aircraft distribution and diffusion over several decades. This includes the tracking of national level modernization efforts as measured by the total number and percentage of past generation aircraft replaced with newer generations. Thus, we can see how individual machines were acquired over time but also how the relative importance of technological considerations varied between states during the late 20th century.

III. Overall Diffusion Trends

There are four distinct trends in airpower diffusion from 1969-2013. First, airpower capabilities, both in terms of aircraft totals and airpower score, are heavily concentrated at the top. Chiefly responsible for this trend were the massive aircraft inventories held by the United States and the Soviet Union during the Cold War. For instance, in 1969 some 46.3% of combat capable aircraft and 51.2% of total airpower capability belonged to the two superpowers. Add in the other permanent members of the UN Security Council and those percentages rise to 60.7% and 63.5%, respectively. Thus, by the late 1960s the international distribution of airpower had become so heavily skewed that nearly two-thirds of global airpower capability rested with just five countries.

The period of airpower concentration did not last long. From 1969 on the proportion of airpower capability held by the United States and Soviet Union steadily declined. This decline accelerated with the end of the Cold War. Figure 10 shows the combined proportion of U.S.-U.S.S.R. airpower over time and its fall from 52.2% in 1969 to 27.5% in 2013. Part of this decline is explained by the proliferation of states and the expansion of the international system. An increase in the number of militaries fielding even small air elements naturally reduces the proportion of airpower capability held by any one existing state. Much of the decline is attributable to major reductions in the quantity of combat aircraft held by the two superpowers. In 1969, the U.S. and U.S.S.R. fielded some 13,564 combat capable aircraft. In 2013 the U.S. and Russia possessed only 5,461 total CCA. This represents a 60% reduction in force. While the total number of aircraft declined in both the U.S. and U.S.S.R., the quality of the replacement aircraft partially made up for this. Case in point, the total combined airpower score only fell by 39% from 1969 to 2013. Going forward it appears that the decline in the total number of aircraft will continue while the relative global proportion of airpower belonging to the United

States and Russia may remain roughly equal. The latter point is evidenced by the small resurgence in the relative global proportion of U.S.-Russia airpower from 2001-2013. In any case, changes in the nature of aerial warfare associated with the proliferation of unmanned aircraft and missile technology will undoubtedly effect how this process plays out over time.

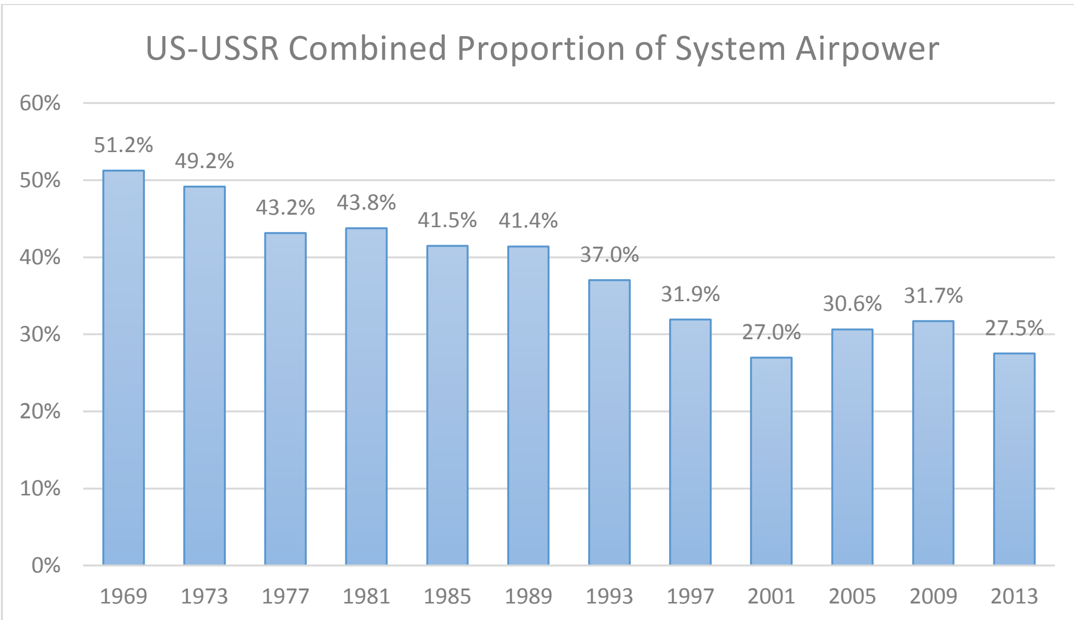

Figure 10: The Concentration of Airpower Capability with the U.S. and U.S.S.R./Russia over Time

The second major trend in airpower diffusion (or, more accurately, distribution) is the variation in airpower scores across regions. The regional differences are stark and have, for the most part, remained constant over time. Figure 11 shows the relative distribution of total airpower capabilities by region. Europe is clearly the dominant region with 40.3% of the total system airpower score. Much of this is accounted for by the inclusion of the U.S.S.R/Russia and the large number of states with advanced conventional military forces. Second in line is North America with 20%. This is almost entirely attributable to the United States. Third is East Asia and the Pacific, a region composed of up to 20 countries, with the majority of airpower capability belonging to

China and, to a lesser extent, Japan, North Korea, South Korea, and Taiwan. With 11.6% of the total, the Middle East and North Africa is notable for its low concentration of airpower capability with any one country. While Israel possesses a qualitative superiority in training, tactics, and personnel, it remains only slightly ahead of its regional rivals when quantitative measures are taken into account (Gordon 2010). The other three regions, namely South and Central Asia, Central and South America, and Sub-Saharan Africa all account for progressively smaller proportions of overall system airpower capabilities.

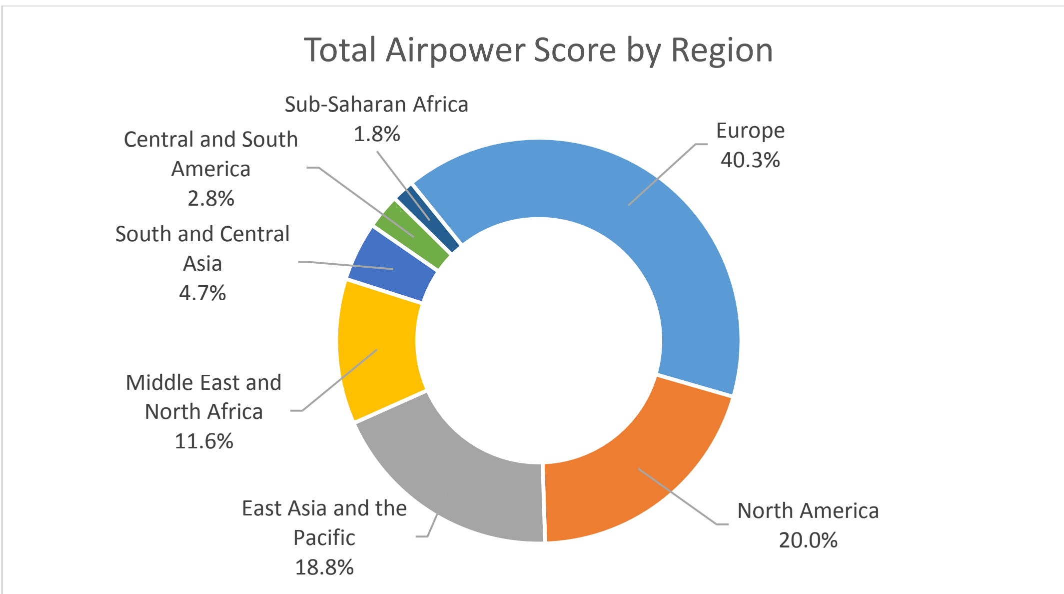

Figure 11: Regional Variation in Airpower Capability

The issue of regional airpower concentration is more clearly presented in Figure 12. Note that North America is omitted from the chart as the extremely high average airpower score caused by the United States would make the scale unusable. The key items of interest on this chart are the average airpower scores by region and the variation between the means and medians within each region. Both speak to the distribution of airpower capabilities. For instance, the high mean scores for East Asia and the Pacific (1,170) and Europe (1,467) indicate that airpower capabilities are substantially higher there than elsewhere on a per state basis. The median scores show, however, that state-for-state, East Asia and the Pacific actually trails the Middle East and North Africa and South and Central Asia. Europe still possesses the highest median score but is much closer to parity with the three other closest regions. Central and South America and Sub-Saharan Africa remain far behind the others. Again, the large disparity in mean and median scores highlights the effect of airpower outliers, namely the U.S.S.R./Russia and China.

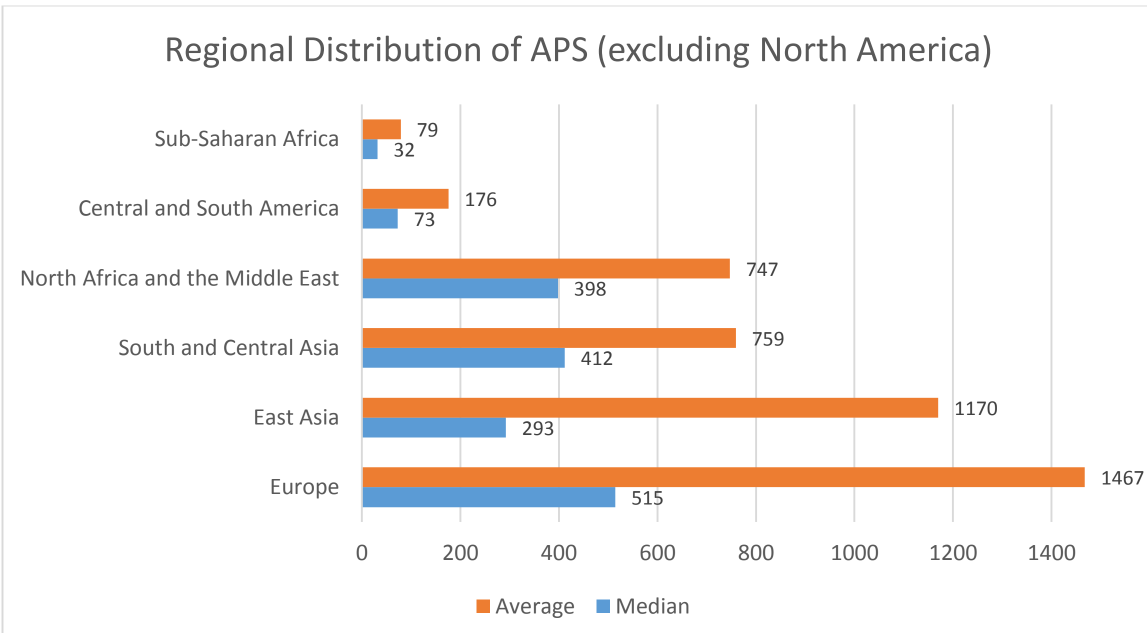

Figure 12: Mean and Median Airpower Scores by Region

The third major trend in airpower diffusion is the steady increase of airpower capabilities up until 1993 and subsequent decline thereafter. Figure 13 illustrates this point. From 1969 to 1993 the total number of combat capable aircraft in the system rose 42.9% while the total system airpower score nearly doubled (97.3% increase). After 1993 there was a stark reversal. Both total combat aircraft and total airpower score fell precipitously over the next two decades. Aircraft numbers and airpower scores fell 48.9% and 42.7% from their highs, respectively. By 2013 the total number of combat aircraft in service globally (21,398) had fallen well below the total in service in 1969 (29,291). Interestingly, on a per state basis, aircraft totals and airpower scores never experienced the initial upward trend. Figure 14 shows that, aside from two brief exceptions (1977-1981 and 1993-1997), median aircraft numbers and airpower scores declined during the entire period under review. It would seem, then, that the negative global trend in airpower capabilities has been ongoing for some time for most members of the international system. It was only with the end of the Cold War that the United States and Russia joined the rest of the global community in the general airpower decline. Again, it is unclear how long this trend will continue.

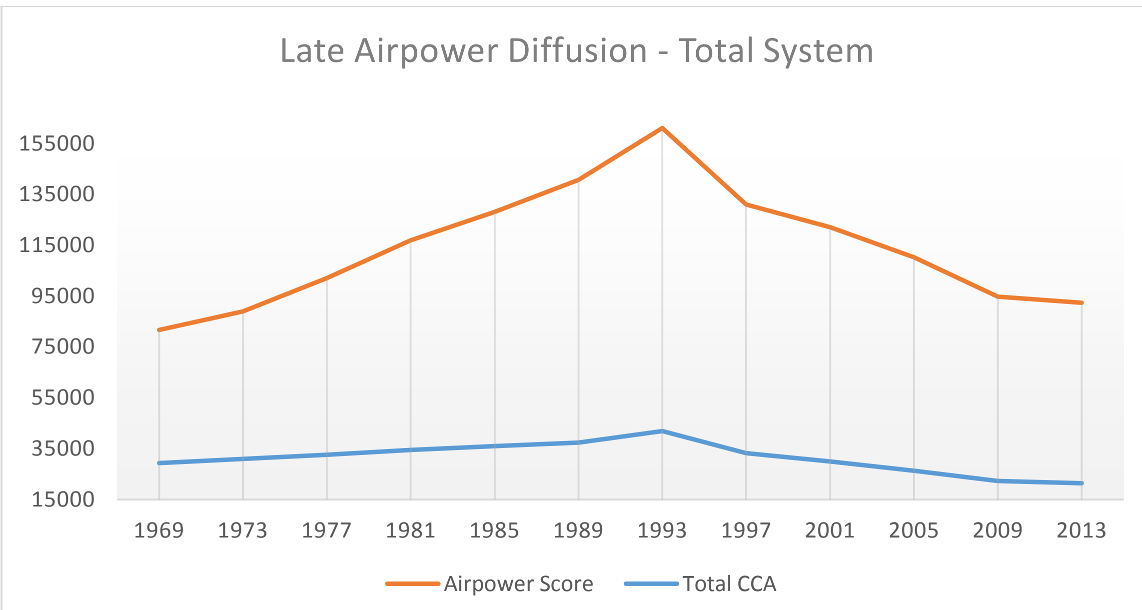

Figure 13: Aircraft Inventories and Airpower Scores from 1969-2013

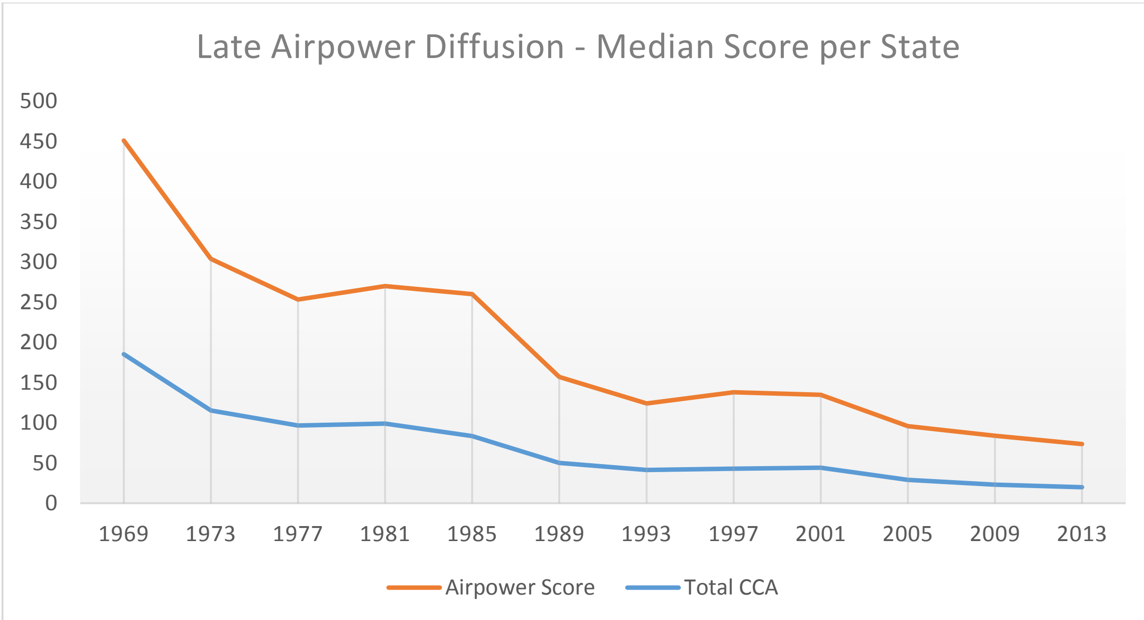

Figure 14: Median Aircraft Inventories and Airpower Scores 1969-2013

The fourth and final major airpower trend deals with the process of aircraft modernization over time (Figure 15). In 1969 the majority of aircraft in service globally were second generation types. Third generation aircraft had only recently been introduced and, over the next few decades, steadily replaced obsolete models. Fourth generation aircraft began to appear in in the mid to late 1970s and grew steadily as a proportion of total aircraft through the 1980s. Since the mid-1990s, though, the total number of fourth generation aircraft in service globally has remained almost constant. In 1997 there were 10,184. In 2013 there were 10,535. At the same time, second and third generation aircraft have steadily declined in number. The total number of third generation aircraft in service peaked in 1993 at 21,425. Twenty years later that number has fallen to 8,718. It appears, then, that much of the decline in airpower capability in the post-Cold War period comes from the retirement of large numbers of older aircraft models without one to one replacement by newer models.

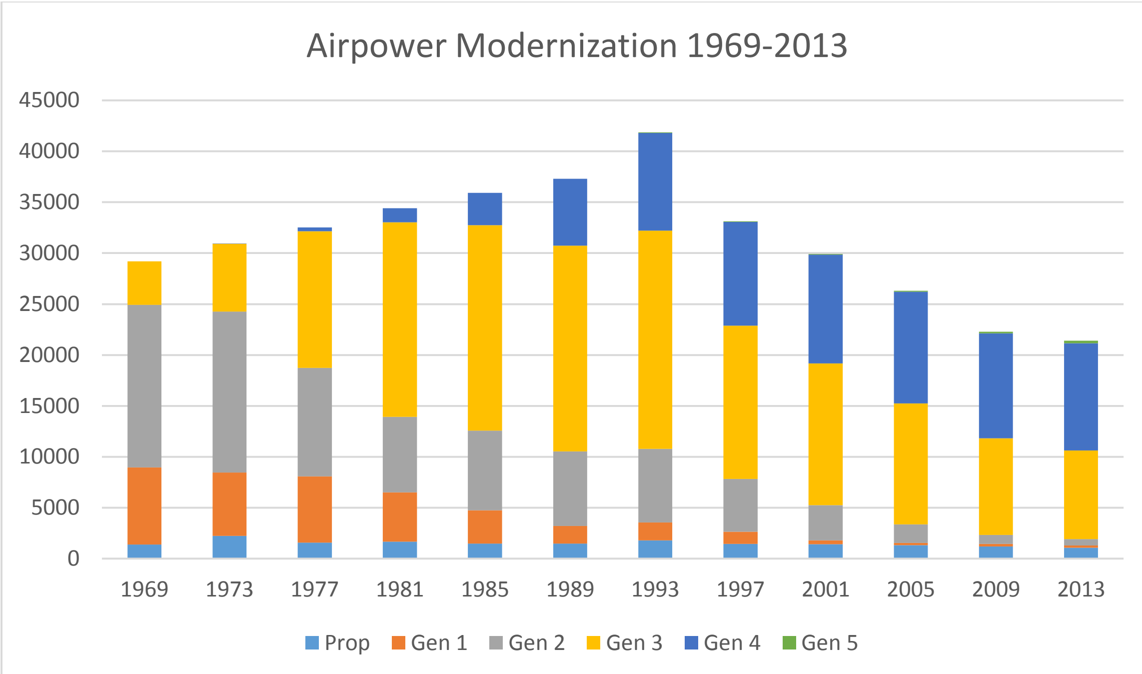

Figure 15: Total Combat Capable Aircraft by Generation by Year

Also of note is the extraordinarily slow rate at which fifth generation types are being introduced. Though the first fifth generation aircraft entered the dataset in 1993, as of 2013, there are only 232 in service. These aircraft represent just 1% of the total number of aircraft in service globally. Even in the United States, the dominant airpower state, the process of generational replacement has proceeded slowly. Figure 16 shows how quickly the U.S. divested itself of its second generation fighters. The move away from third generation aircraft has taken considerably longer but is nearly complete today. At the moment, however, there appears to be little interest in replacing fourth generation aircraft en masse (Tirpak 2009). Case in point, the B-2 and F-22 are the only fifth generation aircraft in service today and both models have completed their production runs. The introduction of the F-35 over the next decade will steadily increase the proportion of fifth generation aircraft in service both in the United States and abroad. However, the F-35 it not slated to replace earlier aircraft on a one for one basis over its planned 30 year production run. As a result, the global downward trend in total combat aircraft is likely to continue for the foreseeable future as aging airframes are withdrawn from service.

In the next decade the refocusing of aviation resources toward unmanned systems, both fixed and rotary-wing, is almost certain to accelerate the downward trend in total manned aircraft (Singer 2009). These new weapons challenge the generational classification system. The utility of identifying aircraft by generation is based on the assumption that the latest generation of aircraft exceed the performance of their predecessors on nearly all measures. The current crop of UAVs in service exceed manned aircraft in select areas like range, loiter time, and cost effectiveness but remain far behind in areas like speed, payload, and maneuverability. Consequently, future analysts will need to devise a new method of classifying aircraft types as the generational approach will no longer apply.[80]

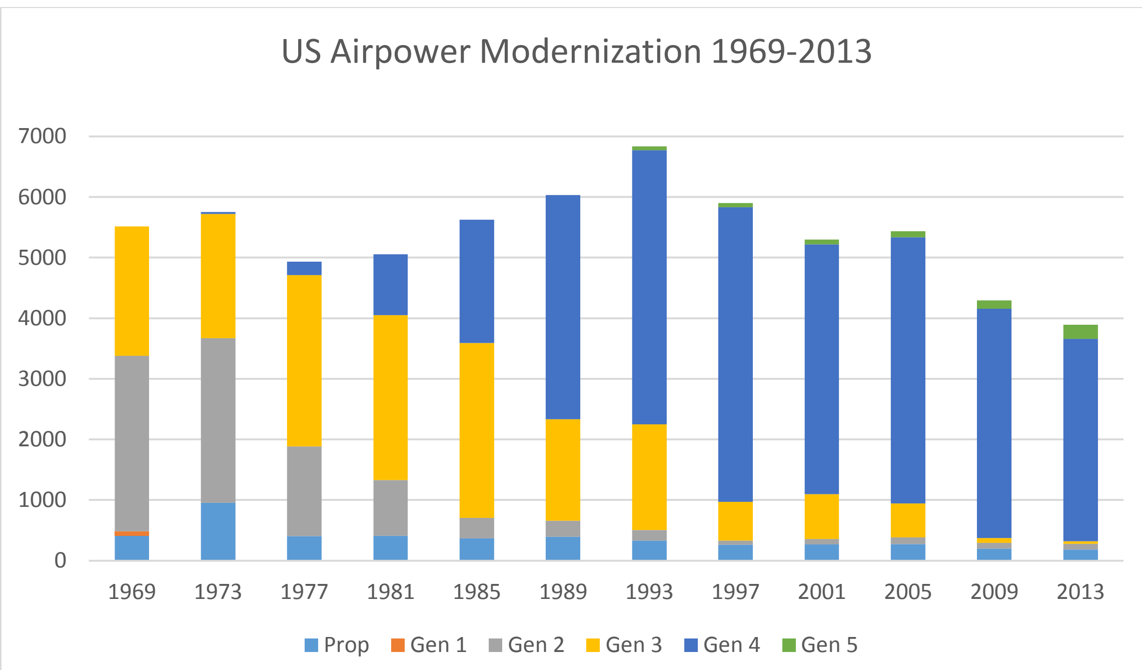

Figure 16: Total U.S. Combat Capable Aircraft by Generation by Year

80 Thankfully the number of armed unmanned aerial vehicles is still relative low today meaning that the coding issues in the dataset were minor. For simplicity sake, armed UAVs were coded as third generation aircraft given their general combat inferiority to fourth generation models.

IV. Testing the Hypotheses

The overall trends in airpower diffusion provide a general overview of how airpower capabilities came to be what they are today. These trends fail, however, to uncover the causal mechanisms driving airpower adoption at the national level. The following section explicitly tests the competing hypotheses presented in Chapter 2 in order to assess the relative impact of each state-level characteristic on national-level airpower adoption intensity. The statistical findings are summarized in the conclusion section.

Before moving to the analysis it is useful to take a brief look at the descriptive statistics on each of the variables. Table 8 displays the mean, standard deviation, and range of both the independent and dependent variables. The first thing to note is the wide variation in aircraft inventories and airpower scores, and their relative skewedness. Aircraft inventories range from zero up to 8,759 while airpower scores go up to 32,087. But the averages for both are only 266 and 951 respectively, this highlights the influence of the outliers at the top, namely the United States and Russia/U.S.S.R. In an effort to normalize the data both variables are logged in the Ordinary Least Squares (OLS) regression model. CINC scores and population also appear to be skewed as well. These variables were also logged in order to normalize the data dispersion and account for heteroscedasticity.

	Variables List	Obs	Mean	Std. Dev.	Min	Max
Dependent Variables	Combat Aircraft Total	1,242	266.41	889.36	0	8,759
	Airpower Score Total	1,241	950.66	3,255.84	0	32,087
Security Concerns	MIDs 5 Year Average	1,059	0.66	1.07	0	13
	Enduring Rivalry	1,084	0.35	0.48	0	1
	Central and South America	1,249	0.15	0.36	0	1
	East Asia and the Pacific	1,249	0.15	0.36	0	1
	Europe	1,249	0.26	0.44	0	1
	Middle East and North Africa	1,249	0.15	0.35	0	1
	North America	1,249	0.02	0.13	0	1
	South and Central Asia	1,249	0.06	0.24	0	1
	Sub-Saharan Africa	1,249	0.21	0.41	0	1
Resources	CINC Score	1,249	0.0079	.0222	0	.1975
	Population	1,249	39,018	125,477	72.0	1,303,720
	Alliances	1,249	0.164	0.371	0	1
Regime Type	Democracy	1,203	0.38	0.48	0	1
Reputation	IGOs	1,249	55.64	20.84	2	126
	Diplomatic Exchanges	1,247	59.96	36.06	0	177
Additional Controls	Fragmentation	1,249	0.09	0.29	0	1
	Cold War	1,249	0.52	0.50	0	1

Table 8: Variable Descriptive Statistics

Each of the independent variables was placed into an OLS regression model in order to determine the relative effect and significance of each state characteristic on airpower scores and aircraft counts. Initially the data was pooled together without regard to temporal dependence. Theoretically, though, this approach did not make much sense. Military aircraft are major capital investments with shelf lives of several decades. Barring a major military conflict, it is unlikely that a state's aircraft inventory will be expended in its entirety over a four year period. Instead, we can expect a good deal of carry over or "inertia" from one time period to the next (Sechser and Saunders 2009, 500).

To test the magnitude of this inertia, airpower score and aircraft counts at time t were regressed on airpower score/aircraft counts at t+1. The results showed that the correlation between observed values at time t and t+1 was very high (.955/.96). Consequently, a lagged dependent variable was added to the right-hand side of the each equation to account for serial autocorrelation. All other variables remained the same. Adding the lagged variable refocuses the model on the influence of each independent variable on the *change* in airpower score over time. Attention shifts from the absolute value of the airpower score to the observed delta from t to t+1, t+1 to t+2, and so on. Additionally, robust standard errors were clustered by country in order to account for inertial effects associated with individual states over time. The new "time-effects" models incorporating the lagged dependent variables are as follows:

Airpower Score = β_1*MIDs5* +B_2*Rivalry* + B_3*CINC Score* + B_4*Population* + B_5*Alliances* + B_6*Democracy* + B_7*IGOs* + B_8*Diplomatic Exchange* + B_9*Region* + B_{10}*Lagged Airpower Score* + *Constant* + *Error Term*

Combat Capable Aircraft = β_1*MIDs5* +B_2*Rivalry* + B_3*CINC Score* + B_4*Population* + B_5*Alliances* + B_6*Democracy* + B_7*IGOs* + B_8*Diplomatic Exchange* + B_9*Region* + B_{10}*Lagged Combat Capable Aircraft*+ *Constant* + *Error Term*

	Airpower Score (APS)			Combat Capable Aircraft (CCA)		
	Beta	R.S.E.	P-Value	Beta	R.S.E.	P-Value
MIDs 5 Year Average	0.018	0.027	0.461	0.026	0.024	0.281
Enduring Rivalry	0.052	0.040	0.196	0.044	0.035	0.217
CINC Score	0.209**	0.042	0.000	0.214**	0.041	0.000
Population	-0.131**	0.032	0.000	-0.112**	0.031	0.000
Alliances	0.049	0.050	0.324	0.019	0.046	0.687
Democracy	-0.025	0.047	0.598	-0.025	0.039	0.528
IGOs	-0.003**	0.001	0.004	-0.003**	0.001	0.002
Diplomatic Exchanges	0.002*	0.001	0.036	0.002	0.001	0.106
Central and South America	0.137	0.107	0.202	0.113	0.113	0.317
East Asia and the Pacific	0.071	0.104	0.500	0.023	0.115	0.844
Europe	0.072	0.086	0.402	0.071	0.102	0.486
Middle East and North Africa	0.179^	0.101	0.077	0.130	0.111	0.247
North America	0.324*	0.135	0.017	0.259^	0.142	0.071
Sub-Saharan Africa	0.137	0.119	0.252	0.063	0.125	0.613
Lagged APS/CCA	0.841**	0.019	0.000	0.811**	0.020	0.000
Constant	3.343**	0.590	0.000	3.177**	0.568	0.000
	N = 748 R^2 = .94			N = 748 R^2 = .937		
*Notes: ^p<.10, *p<.05, **p<.01*						

Table 9: OLS Regression on Airpower Score and Combat Capable Aircraft

The first thing to notice in the OLS regression results is the very high coefficient on each of the lagged variables (.841/.811). Obviously in this sample the best predictor of a state's airpower score and total combat aircraft inventory are its airpower score/aircraft count four years prior. More interesting, though, are the coefficients on the other covariates. Note that neither of the threat variables, MIDs nor Enduring Rivalry, are statistically significant. In contrast, two of the resource variables, CINC score and population, appear to influence the dependent variables in both models, albeit in opposite directions. CINC score is positively correlated with airpower score and total combat capable aircraft (.209/.214) and statistically significant at the .01 level. Population is negatively correlated with both (-.131/-.112) and significant at the .01 level as well.

The coefficients on IGO membership and diplomatic exchanges are both statistically significant but point in different directions. IGO membership is negatively correlated with both airpower score and total aircraft counts (-.003/-.003), a finding that is statistically significant at the .01 level in both models. This is the opposite of the expected direction as outlined in chapter 2. Diplomatic exchange is positively correlated with both airpower score and total aircraft count (.002/.002) but is only statistically significant (.05 level) in the airpower score model. It appears, then, that for each additional IGO a country is a member of its airpower score is reduced by .3% while for each additional diplomatic posting a state establishes its airpower score rises by .2%.

Only two of the regional variables included in the model display any statistically significant findings. Remember that since region is a categorical variable it must be broken down into a series of dummy variables in order to be included in the OLS regression. One of the regions, in this case Central and South Asia, was excluded from the model and serves as a reference. The coefficients on the remaining regional variables should be interpreted relative to the excluded variable. For example, the positive signs on North America (.324) and the Middle East and North Africa (.179) in the airpower score model indicate that, in the presence of controls, both regions have higher airpower scores relative to Central and South Asia. The coefficient on North America is statistically significant at the .05 level while the coefficient on the Middle East and North Africa is significant at the .1 level. The first model produces an R^2 value of .94 while the second model produces a similar R^2 value of .937.

V. Findings and Conclusions

The findings suggest there are several factors influencing airpower adoption intensity in the late 20th century. The prime determinant is national military resources (H_5). Simply put, states with greater overall military resource capacity have stronger airpower capabilities. This comes as no surprise. Airpower is a capital-intense form of military power requiring substantial financial investments, usually over a period of time. The importance of military resources has only increased over time as combat aircraft costs have grown dramatically (Arena et al. 2008). While per-unit aircraft costs have increased so also has the variety, sophistication, and cost of the supporting equipment and facilities necessary to conduct aerial operations. The extraordinary expense of airpower limits its appeal when compared to other, more efficient methods of generating military power. Ultimately, states with large defense budgets can absorb the costs of acquiring aircraft, and will choose to do so. States with limited defense resources cannot and will not.

The second key determinant is population (H_6). It appears that, when controlling for other factors, states with small populations tend to have higher airpower scores and larger numbers of combat capable aircraft. This supports the notion that small states intentionally engage in a capital for labor substitution policy. Substituting aircraft for men then allows them to enhance their overall military and force projection capabilities without having to rely on large standing armies.

The third key determinant is the number of diplomatic exchanges (H_{10}). On average, states with strong diplomatic presence have stronger airpower capabilities. This supports the notion that international interaction facilitates innovation diffusion. The specific mechanisms of interaction, whether they be purely civilian diplomatic exchange, mil-to-mil collaboration, or simply an indication of greater openness to foreign innovations (military or civilian), remains to be seen. But the notion that greater diplomatic presence improves information collection on foreign weapons and tactics is broadly supported by the data. It should be noted that the diplomatic exchange variable only reaches the threshold of statistical significance in the airpower score more and not the combat capable aircraft model.

The fourth determinant is intergovernmental organization membership (IGOs) (H_9). Unlike the three previous factors, IGO membership is negatively correlated with airpower capabilities and thus it appears that more internationally engaged states are actually less likely to pursue airpower. This is in stark contrast to the qualitative and quantitative evidence presented in prior chapters. Whereas early airpower diffusion rate and intensity was shaped by status concerns, in the latter 20th century this effect reversed itself. This could indicate that airpower may have lost its institutional meaning over the course of the century (though Eyre and Suchman would argue otherwise). It could also be a matter of the proliferation of IGOs and the availability of membership to newer, smaller states with less capacity to purchase and field military aircraft. A third explanation could be that more internationally connected states rely more heavily on collective security and diplomacy for their defense and, as a result, do not feel the need to invest large sums on military aircraft and equipment. Ultimately, the exact mechanism at work here is unclear. This opens up an excellent avenue for future research.

Interestingly, it appears that neither a history of militarized interstate disputes nor pre-existing enduring rivalries have much of an effect on airpower capabilities (H_3 and H_4). Contrasts this with the evidence from the case study on the early airpower period in which external threats directly influenced the intensity of airpower adoption in pre-war Europe. In order to test the robustness of this finding I omitted the MIDs and Rivalry variables independently. Doing so produced no noticeable change to the results. Again this seems to indicate that when national military resources are accounted for external threats have little bearing on airpower capabilities.

The notion that democratic states will pursue airpower more vigorously than their autocratic counterparts is not supported by the data (H_8). In both models the coefficient on democracy is in the opposite direction of what is expected but it fails to reach the .1 threshold for statistical significance. The lack of significant findings in either model is in line with the lack of evidence in the last chapter. It would seem that democracy has no noticeable effect on airpower adoption patterns. If anything, the qualitative evidence from the early airpower period indicates that democratic political institution may in fact inhibit rather than promote airpower adoption.

The relationship between region and airpower is complex (H_2). First, it is quite clear from the descriptive statistics that the regional distribution of airpower capabilities is heavily skewed. Europe is the dominant airpower region, followed by North America, East Asia and the Pacific, and the Middle East and North Africa. When controlling for other factors, though, North America and North Africa and the Middle East display higher overall values in both models compared with the reference region, Central and South Asia. None of the other regional groups exhibit statistically significant effects on airpower score or total combat capable aircraft.

The influence of regional membership on airpower scores is difficult to assess in the late 20th century because the time period begins at a point when the distribution of airpower was already set. Viewed statically the regional concentration of airpower capabilities seems to confirm the notion that proximate threats drive aircraft acquisitions. We can conclude, then, that airpower capabilities are heavily clustered by region but that the influence of regions on the change in this distribution over time is negligible. Case in point, when the regional variables are dropped from the regression model the findings on the remaining variables change only slightly.

One potentially influential factor comes from the time period covered in the data. As noted above, total system airpower capabilities peaked right at the midpoint in the dataset. There was a clear rise on the left hand side of this peak and a clear fall afterward. In looking at the time-series data it could be that this unique low-high-low pattern is canceling out much of the variance and thus it appears that there has been little change at all from the beginning to the end of the dataset. A passing glance at the starting and ending airpower scores in 1969 and 2013 would seem to indicate a rather mild transition has occurred (roughly a 27% decrease in airpower score). Thus, the shape of the airpower data over this specific time period could be suppressing the effect of regional membership on airpower scores. Expanding the dataset further back in time, or alternatively, starting it at the end of the Cold War would reduce the impact of the central peak. This could potentially show that regional influence is more clearly discernible in periods of sustained growth or sustained decline. In order to account for this a Cold War dummy variable was included in the model. The new variable was not, however, statistically significant nor did it substantially alter the coefficients on any of the other variables in either model.

The notion that alliance structures help facilitate or encourage greater airpower adoption is not supported (H_7). In the output table above the variable Alliances consists of all states in the international system that were members of either the North Atlantic Treaty Organization (NATO) or the Warsaw Pact in a given year. Constructed in this manner the variable was placed into both models but ultimately failed to produce significant results. Disaggregating the variable into two variables, NATO only and Warsaw Pact only, had little effect. It seems then that the dominant alliances patterns of the latter 20th century had minimal impact on airpower adoption intensity.

Finally, it is important to remember that the circumstances of independence varied widely across the international community. While many states began as colonial possessions, others attained independence from previously existing political entities with well-established airpower capabilities. Chief among these are the East European states in the Balkans and former Soviet Union that came into being in the early 1990s. Unlike former colonies in Africa, these "descendent states" could rely on established military institutions and equipment acquired over the prior period of national union. As such, we would expect that newly independent countries born of out of a process of state fragmentation to have greater airpower capabilities than those born out of decolonization. To test this a new dummy variable was constructed (Fragmentation) to identify the former colonies from the former sovereigns. Including this variable in the model as a robustness check produced no noticeable changes to the results.

Chapter 6: Conclusion

The purpose of this dissertation is to identify the determinants of military airpower diffusion in the 20th century. Doing so required the use of multiple methodologies across a range of sample populations over three distinct time periods. Chapter 3 looked exclusively at the period of innovation emergence, concentrating specifically on the internal adoption dynamics of the major powers of the era and how variance in national characteristics influenced airpower adoption intensity. Chapter 4 built upon this foundation by expanding the sample to include all countries in existence at the time of innovation emergence and by focusing on the airpower adoption rate. The larger sample size (44) allowed for the use of statistical techniques to assess the impact of state characteristics on time to adoption. Chapter 5 focused on a still wider sample to assess the influence of national characteristics on airpower adoption intensity in the modern age. This concluding chapter seeks to synthesize these findings into a coherent model of military airpower diffusion. The proposed model, which takes two separate forms based on the time period, is meant to guide future research into military innovation diffusion.

I. Two Proposed Models of Airpower Diffusion

In the early 20th century military airpower diffusion was driven by a mix of security, resource, and status concerns. The diffusion process, which includes both the initial airpower adoption rate and, more importantly, adoption intensity, involved three stages. The stages represent a progressive series of conditions that, when met, resulted in earlier and more intense airpower adoption (See Figure 17). The first condition was the existence of a clear external threat. The presence of a potential enemy, particularly one of relatively equal capability, heightened national levels of insecurity thereby encouraging increased military spending and the pursuit of innovative military technologies with which to gain an advantage over an opponent. Germany's intense rivalry with France, for instance, buoyed the Prussian General Staff arguments for further resources with which to acquire technology, aircraft included, that would ensure German superiority (or at least parity). The external threat therefore served as the underlying cause for arms acquisitions generally.[81]

In the presence of an external threat there was no guarantee that a state would pursue airpower over other alternative forms of military power. There were, however, two facilitating conditions that if met, improved the odds of airpower adoption. The first was resource availability. In order to acquire aircraft states needed to have funds available to do so. Among the major powers funding was usually sufficient for at least a small aviation contingent. But among the wider international community defense spending was limited. Aircraft purchases were relatively large expenditures and therefore less attractive as potential military options. This explains why in the duration model CINC score produced the highest hazard ratio (2.117) and thus the greatest influence on the airpower adoption rate.

The second facilitating condition was status. In the pre-WWI era, aircraft represented some of the most modern, sophisticated military technologies of the day. Though the practical utility of the airplane as a weapon of war was uncertain[82], its symbolic utility as an indicator of national technological achievement was high. As a result, states concerned about national status were apt to acquire airpower in order to enhance national prestige. The acquisition of military aircraft and the establishment of a military aviation arm projected an image of technological sophistication. States that were

[81] I recognize that neither the MIDs nor rivalry variables were significant in the duration model. I suspect that the lack of statistical findings on these variables (particularly rivalry) is due to the small sample size (44). As such, I do not feel that a lack of statistical significance in the duration model negates the importance of external threat given the qualitative evidence.
[82] The indecisive role of airpower in Libya and the decidedly negative experience in Mexico were contributing factors in Europe and the United States.

more deeply connected with the international community via intergovernmental organizations, and therefore more concerned about relative status among their peers, were more apt to acquire airpower. The positive relationship between IGOs and airpower adoption rate supports this claim. Additionally, the case study showed that French national pride in its aviation leadership, and the Russian perception of technological inferiority, contributed to airpower acquisition decisions in both countries. Though driven by slightly different motivations, the goal for both Russia and France was, ultimately, to enhance their national reputations as technically advanced, modern states through the acquisition and development of airpower capabilities.

The third stage of the early airpower adoption process involved domestic advocacy, specifically pressure applied by the mass public on governments to pursue the military aircraft. This pressure then served as the proximate cause of airpower adoption. Now, as seen in the case study, a general interest in aviation was common across all the major powers. But in select cases this interest, which came in the form of national fundraising campaigns, newspaper editorials, and aviation prizes was particularly intense and sustained. France and Germany are the two prominent examples. In both countries public support for aviation, as displayed in airshow attendance and private donations, was high. Driven in no small part by nationalist fervor, public advocacy for aviation eased the burden on aviation advocates within the government, providing them a base of support upon which to lobby for aircraft purchases. In Austria-Hungary, a state hindered by deep domestic political fissures, there was little shared nationalist sentiment and thus a key factor in the pro-aviation movement was lacking. Even in Britain, a relatively weak airpower adopter, the influence of the public was crucial. When the British government finally reversed its decision on aviation funding, its about-face was largely the result of public pressure brought on by the "Phantom Airship Scare of 1909" (Gollin 1981, 43).

Finally, the last element in the airpower diffusion process, diplomatic exchange, is not necessarily a stage or condition, but rather a mechanism through which knowledge and information on aviation advancements were communicated across the international community. In the earlier 20th century basic information on aviation was lacking. This was due in large part to the relative newness of the technology and the incredible rate at which aviation technology was advancing. Political appropriators and military leaders depended on their representatives abroad, both diplomatic and military liaisons, to gather accurate intelligence on foreign technological developments and to monitor the response of local governments to these developments. The utility of the information that traveled via diplomatic channels is evident in the attaché reports from Libya and the Balkans. That no relationship appears in the duration model is not altogether surprising. Knowledge of initial aircraft purchases was generally well-reported in newspapers and aviation journals. Diplomatic channels were more useful in assessing the level of airpower capability (adoption intensity) and aviation experience (both in maneuvers and in combat), possessed by foreign governments and their militaries. Diplomatic exchanges were ultimately more influential in determining adoption intensity than adoption rate.

Model I: Early Airpower Adoption Process

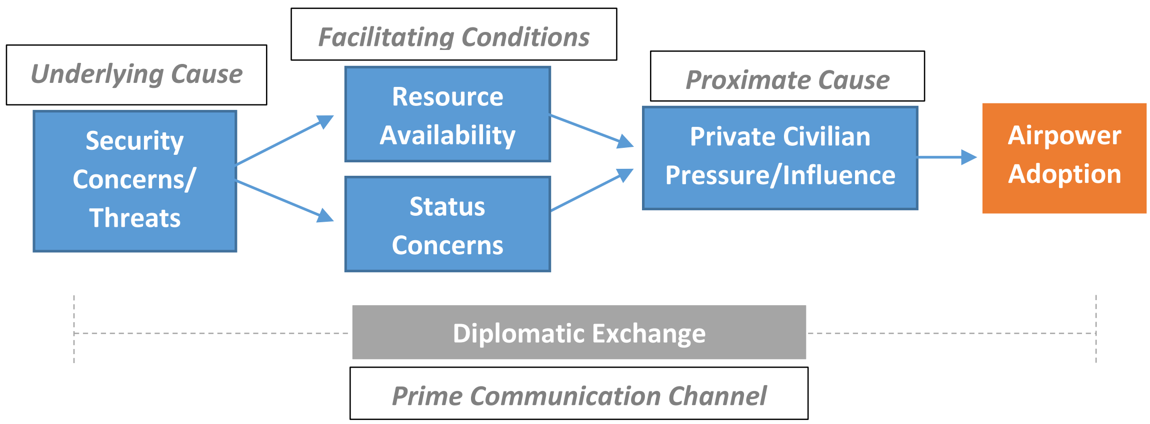

Figure 17: A Proposed Model of Early Airpower Diffusion Processes

The process of airpower diffusion morphed over the course of the 20th century. Changes in the international political environment and advancements in aviation technology profoundly altered both the nature of military airpower and its perception among the international community. As a result, a second proposed model of airpower diffusion focused on airpower adoption patterns in the late 20th century is presented in Figure 18. This model retains most of the basic elements of the first model, but does include two important changes. These changes illustrate a partial shift in airpower diffusion determinants over time.

The first thing to notice in the late airpower diffusion model is that resource availability continues to be a prime determinant of airpower adoption intensity. As noted above, the availability of resources is key to acquiring aviation forces, perhaps even more so today when individual aircraft have become prohibitively expensive. Additionally, diplomatic channels continue to be a useful resource in transmitting information and knowledge on military aviation technology, foreign military forces, and second hand battlefield experiences. Note the positive relationship between diplomatic exchange and airpower capabilities, even in the presence of controls.

The more interesting aspects are the elements that differ from the early airpower diffusion model. For one, status concerns are no longer a facilitating condition. Rather, in the late 20th century, status concerns have become an inhibiting factor to airpower adoption intensity. States that are party to large numbers of intergovernmental organizations are actually *less* likely to pursue airpower. Instead, those states with fewer international connections have generally seen a larger increase in airpower capabilities – both in terms of the number of machines and their quality. This could mean one of two things. It is possible, of course, that airpower has lost its symbolic utility over the course of the 20th century. No longer capable of projecting a halo of modernity over its possessor, the military aircraft has become a standard, conventional weapon system. With no intrinsic value beyond its physical capabilities the justification for the spiraling costs of modern aircraft are difficult to support. This then discourages future aircraft purchases thereby leading to a general system-wide decay in airpower capabilities as older aircraft fade out of service.

The other possibility could be that states with deeper connections to the international community generally feel safer, anticipate less conflict, and are therefore less likely to pursue airpower. Russett et al. find, for instance, that increasing IGO membership by one standard deviation results in a 23% decrease in militarized disputes among neighboring states (1998). This indicates that states with high IGO membership levels experience more peaceful international relations. Thus, the proliferation of IGO membership could very well be suppressing the intensity of external threats thereby eliminating the underlying cause in the model. This would produce the observed negative effect on airpower adoption intensity. This seems the more plausible explanation, though further research is required.

The second major change is the introduction of population constraints as an aiding factor in airpower adoption intensity. The output from both models in the late airpower period indicates that total state population is inversely correlated with airpower capabilities. It would seem that political leaders in sparsely populated states recognize their relative strategic disadvantages and attempt to ameliorate them but acquiring military equipment with low personnel requirements but high destructive capacity. This explains why small states like Israel or Norway have disproportionately largely Air Forces relative to the rest of the world. The aerial weapon allows them to project military power and national strength without having to rely on large standing armies. The proposed model of late airpower adoption is presented in Figure 18.

Model II: Late Airpower Adoption Process

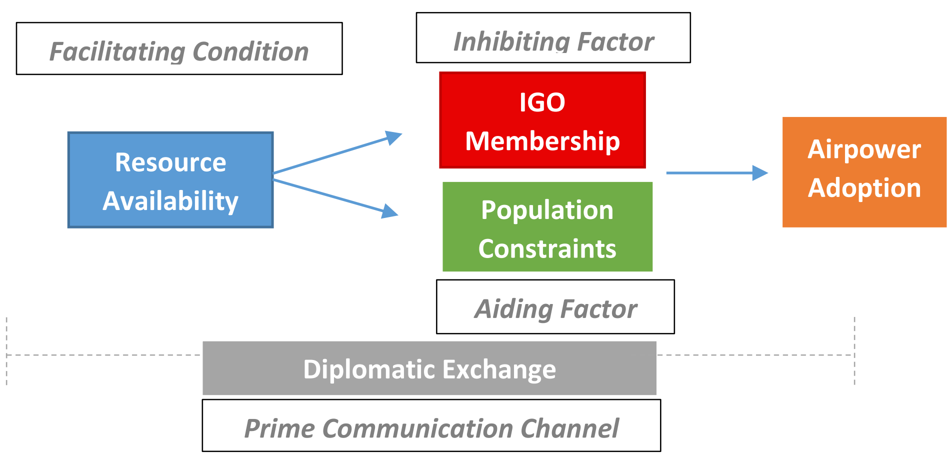

Figure 18: A Proposed Model for Late Airpower Diffusion Process

Together the two proposed models account for airpower diffusion patterns across the early and late 20th century. They show that the determinants of airpower adoption intensity were not static; rather changes in the international environment affected how airpower was perceived and what function it performed. It is important to note, however, that these models are not meant to be definitive. Instead, they are intended to help guide future research into military innovation diffusion in order to understand what factors, whether temporary or permanent, determine how states structure their military forces as a whole.

II. Future Research Avenues

Future research can build upon the findings presented here in several ways. First, the connection between diplomatic presence and military innovation diffusion should be explored further. For instance, one approach would be to look specifically at the role of modern military attaché offices in transmitting intelligence on technical advances in weaponry and, more importantly, how this intelligence plays into national force structuring decisions. I, for one, would be interested to know the degree to which open-source information on weapons technology and designs is supplemented by attaché reporting in country and, also, how this might vary from one country to the next. It would also be valuable to assess the utility of diplomatic communication channels across time periods to see if advances in communication technologies and media coverage have made diplomatic information more or less relevant to the policymaking process.

Second, it would be useful to delve deeper into the relationship between population and national military force structuring. It would be interesting to investigate the relative importance of national wealth or economic development in allowing states to make the population-driven capital-for-labor substitution decisions. For instance, in the model produced here it is difficult to discern specific levels at which capital costs outweigh labor costs in weaponry substitution calculations. This could be ascertained with greater certainty if further data was collected and made available. Moreover, it may be that substitution patterns are not static across the full range of states. It could be, for instance, that airpower capabilities are more aggressively pursued by states within a certain population range (one that, perhaps, excludes micro-states). In any case, this line of inquiry would contribute to the wider literature on weapons acquisitions and national force structuring.

Lastly, future work on military innovations in general should look across a range of cases to see if there are distinct characteristics inherent to the innovations themselves that influence the pattern by which they spread. In this regard, I mean looking beyond simple "capital-intensity" and more toward the methods of employment based on national-level security considerations in future conflicts. This could shed light on adoption dynamics not related to the states themselves but rather to the equipment and methods they adopt for national defense.

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