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Buying a Better Air Force

Jenny O. Herald

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THESIS

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AFIT/GCA/ENV/06M-05

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BUYING A BETTER AIR FORCE

THESIS

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Abstract

The purpose of this study was twofold: to capture the United States (US) government's revealed preference for air superiority using the hedonic pricing approach (HPA) and compare the characteristics of United States Air Force (USAF) fighter aircraft with those of the former Soviet Union to evaluate the effectiveness of the USAF fleet. The resulting analysis showed that the US government is paying for physical and performance characteristics such as engine thrust, service ceiling, range, and large scale integrated circuit technology. However, evidence suggests the government is not paying to have a relative advantage over the enemy based on the physical and performance characteristics analyzed.

Acknowledgments

I would like to extend my sincere appreciation to my thesis chair, Dr. Michael Hicks, for his patience, insight, support, and guidance during this process. Special thanks also go to Maj Sonia Leach and Maj Jeffrey Smith, who served on my committee and spent their valuable time assisting me in this research effort.

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Jenny C. O. Herald

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I. Introduction

Background

If we lose the war in the air, we lose the war and we lose it very quickly.

-Viscount Montgomery of Alamein

United States (US) fighter aircraft were called upon to secure the skies and maintain air superiority as early as World War I. In recent years, the US government has set a new and higher standard for airpower. Hallion (1999:4) states,

> Today, wars typically start, are prosecuted, and reach their decisive culminating point – whether surrender of a foe, agreement to a cease-fire, or the ceasing of combat operations – thanks to air action. Given these circumstances, to lose control of the air is to lose a war, particularly in an era (as we now are in since the end of the Cold War) when deployable overseas forces are small, and thus, particularly vulnerable to the tremendous leverage an opponent gains by sudden and swift air attack.

As such, the goal now is to dominate the airspace over a battlefield and not just overcome the enemy.

If the US does not have clear control of the air while fighting a nation that has equivalent or near-equivalent forces, US military operations are constrained. Thus air superiority forces must fight both defensively and offensively: ensuring “their own survival before fulfilling whatever mission objectives they are trying to achieve” (Hallion, 1999:4). Otherwise the dangers of parity air war are far reaching: potentially affecting air, space, surface, sub-surface operations, and the home front. For example, a shower of bombs and guided missiles from enemy bombers on a naval fleet can be devastating to US shipping operations. "Further, since damaged or sunken ships carry a large price-tag of national prestige and, even worse, lives, the loss or damage of even a single major vessel can have a shattering impact upon public opinion and resolve" (Hallion, 1994:5).

Therefore, it is evident that the US needs to secure and maintain control of the air. "Broadly speaking, control of the air enables a nation to prosecute the fullest range of offensive operations by all its forces against a foe, while, at the same time, insulating those forces defensively from meaningful enemy counterattacks" (Hallion, 1994:5). Former Secretary William Perry suggested in the 1997 defense budget proposal that he was willing to pay a premium to achieve this level of air superiority. To that end, the US government has invested in advances in aircraft technology and training regimes, which has led to impressive aircraft performance capabilities and skilled pilots, albeit accompanied by rising costs.

Problem

The General Accountability Office (GAO) reported that the Department of Defense (DoD) plans on "increasing future aircraft acquisition funding – sometimes approaching Cold-War era spending levels" (GAO/T-NSIAD-97-103, 1997b: 3). It is estimated that the Department of Defense will spend upwards of $31.7 billion in aircraft procurement and research, test, and development efforts this year as seen in Figure 1. With the controversial F/A-22 and Joint Strike Fighter (JSF) programs underway and legacy aircraft systems growing older, becoming more difficult to maintain and relatively less capable, a great deal of reports and research have addressed both the need and cost of modernization[1]. However, little research has been conducted concerning the benefits modernization has provided and what the US government has been willing to pay for these benefits; specifically, quantifying the construct of air superiority. This study can assist decision makers within the Department of Defense to evaluate the effectiveness of United States Air Force (USAF) fighter aircraft in an era where budget constraints force them to work with limited resources. In a NASA Langley Research Center report, Spearman states in reference to fighter aircraft characteristics and trends, "Questions that may be asked—'Are you getting what you are paying for?' or 'Do you need what you are getting?' are easily asked but, again, difficult to answer" (Spearman, 1984:6).

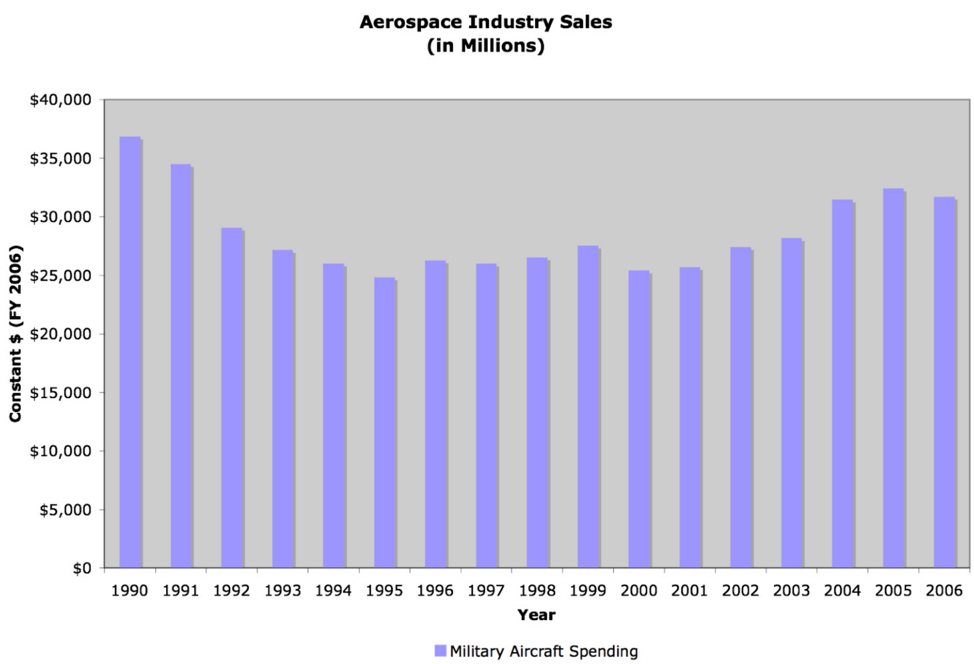

Figure 1. Military Aircraft Spending

The nation's revealed preference for national defense or characteristics of national defense are important but often ignored research questions. In this current acquisition

[1] See, for example, GAO/NSIAD-97-77 (1997a), GAO-03-775 (2003), Hampton (1998), Browne (1998), Spearman (1984), and Morehead (1973).

environment, it is important for the DoD to understand and find answers for such questions. In this study, revealed preference and hedonic pricing theory will aid in evaluating the effectiveness and value of the USAF fleet.

Research Question

The purpose of this research is to capture the government's revealed preference for air superiority using the hedonic pricing approach (HPA). The US has been ever vigilant in maintaining an asymmetric warfare advantage, especially in the arena of aerial combat, where the advantage wholly and completely favors American forces to capitalize on demonstrated capabilities and strengths. The combination of technically sophisticated aircraft design, precise weapons systems, and superior training significantly increases the chance of US military operation success. The sophistication of US fighter aircraft design and capabilities in relation to emerging threat technologies is of particular interest in this research. As mentioned earlier, the US government is willing to pay a premium to secure and maintain control of the air, a premium that can be implicitly estimated using a non-market valuation method.

Investigative Questions (IQ)

This study will attempt to answer two questions: (1) What is the US government's revealed preference for ensuring airspace dominance? (2) Has the US government purchased fighter aircraft that are inferior, superior, or comparable to threat technologies, namely the former Soviet Union? Both of these questions speak to the historical value of government demand for air superiority.

Summary of Current Knowledge

The Air Force Doctrine Document 1 outlines six distinctive capabilities that "represent the combination of professional knowledge, air and space power expertise, and technological fluency that, when applied, produces superior military capabilities or effects" (DAF, 2003:76).

Distinctive Capabilities
Air and Space Superiority **Information Superiority** **Global Attack** **Precision Engagement** **Rapid Global Mobility** **Agile Combat Support**

Figure 2. Distinctive Capabilities (DAF, 2003:76)

These distinctive capabilities are built upon air superiority, "the degree of dominance that permits friendly land, sea, air, and space forces to operate at a given time and place without prohibitive interference by the opposing force," (DAF, 2003:77) a foundational concept critical for mission success.

> The Joint Chiefs of Staff, in its assessment of US air superiority capability, divided it into five distinct missions. Two missions involved offensive air superiority operations to defeat enemy fighter aircraft and surface-to-air defenses within enemy territory, and three involved defensive air superiority to protect friendly territory against enemy aircraft, cruise missiles, and theater ballistic missiles. (GAO/NSIAD-97-77, 1997a:19)

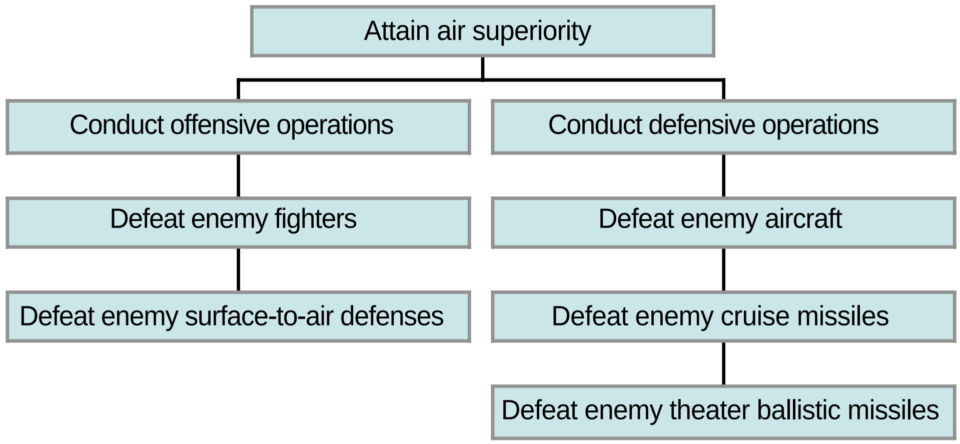

Figure 3. The Missions of Air Superiority (GAO/NSIAD-97-77, 1997a:5)

The DoD planned to "include over $43 billion from fiscal year 1996 to fiscal year 2001 for the acquisition of systems dedicated to the air superiority mission" across all defense services where "most of the planned funding was for the acquisition of aircraft to defeat enemy aircraft, and defensive systems to defeat enemy theater ballistic missiles" (GAO/NSIAD-97-77, 1997a:19). This research will investigate aircraft acquisitions designed to combat enemy aircraft and will assess the value the US government has placed on achieving air superiority.

Degrees of controlling air and space are possible, ranging from paralysis to supremacy (Hallion, 1999:6). "Air paralysis typifies a nation unable to undertake offensive military action of any significance because it is controlled by enemy air forces; there is no hope of victory, and the enemy has air supremacy" (Hallion, 1996:6). "Supremacy is that degree of superiority wherein opposing air and space forces are incapable of effective interference anywhere in a given theater of operations" (DAF, 2003:77). During the Gulf War in 1991, US-led coalition forces enjoyed air supremacy, however, "the coalition had seven months to deploy and build up forces before launching its counteroffensive" (Hampton, 1998:6). Though the preferred degree of control is air and space supremacy, as witnessed by the operations of the Gulf War, achieving air supremacy exacts a high price. Therefore "superiority, even local or mission-specific superiority, may provide sufficient freedom of action to accomplish assigned objectives" (DAF, 2003:77). A RAND corporation study conducted in late 1993 concluded that "the lesson from the Gulf War is not that the US has enough airpower to meet future needs but that the capabilities exhibited in that war are a national asset that Washington should preserve or extend" (Shaver and others, 1994:46-52).

Defense spending seems likely to grow the next few years, despite the high US federal deficit, forecasted to amount around $521 billion this fiscal year. A key factor, threats to US security, is "likely to remain high for several years, as we work to complete our missions in Afghanistan and Iraq and as terrorists continue to pose threats to our interests at home and abroad. The likelihood of a continued defense buildup is heightened by administration plans that call for modest growth in the defense budget, which makes it easier for Congress to support such growth even in the face of large budget deficits" (Hale, 2004:26). A portion of the defense budget is allocated for fielding weapons systems that secure US success in current operations in Afghanistan and Iraq, deploying weapons systems for gaining air superiority in these combat zones, and the modernization of systems for gaining and maintaining air superiority in hostile areas that the US will oversee in the future. "Although air superiority missions have many components, and many types of equipment are involved, the acquisition of US fighter aircraft with the capability to defeat enemy fighters and other aircraft is expected to consume about 47 percent of the resources planned for air superiority missions"

(GAO/NSIAD-97-77, 1997a:21). With a large portion of defense spending for air superiority missions dedicated to the acquisition of US fighter aircraft, it is crucial that the DoD have adequate analytical support for making decisions about proceeding with the acquisition of new tactical fighters or investing in modifications for current fighter aircraft in the Air Force inventory.

Assumptions

Several assumptions are made in this research. First, an assumption was made that only fighter aircraft are representative of the air superiority mission. Second, the researcher assumes that the appropriate model is a hedonic pricing approach. Third, the cost used for each US aircraft is the 100th unit flyaway cost. Some may argue that many US aircraft platforms fought several enemy planes. So, a fourth and final assumption is that each US aircraft will be compared to an enemy aircraft it was designed to combat. This determination is made using historical background and coupling planes based on the year the aircraft became operational.

Proposed Methodology

This research is accomplished using a hedonic pricing technique to produce a model that incorporates historical characteristics of aircraft, such as payload, speed, and aircraft costs, to approximate the premium the government has been willing to pay to develop and maintain a formidable fleet of aircraft. This research will compare physical and performance capabilities of both US and enemy aircraft. The data will be collected from the Air Force Museum, Jane’s Defense database, various books from the Air Force History Office, and Bill Gunston’s *Osprey Encyclopedia of Russian Aircraft*.

Scope of Research

This research focuses on US fighter aircraft and their variants from the post-World War II era to present, as well as combatant enemy aircraft built and flown by the former Soviet Union. Only Air Force aircraft that have been fielded will be used in the analysis. This research will address several characteristics for each plane. The number of variables in the hedonic model will be limited to the number of data points, or US and former USSR aircraft, that are available.

II. Literature Review

General Issue

To quote J.F.C. Fuller, a Major General in the British army, military historian, and strategist,

> It is absolutely true in war, were other things equal, that numbers – whether men, shells, bombs, etc. – would be supreme. Yet it is also absolutely true that other things are never equal and can never be equal. There is always a difference, and it is the differences, which by begging to differ so frequently throw all calculations to the winds. (Westenhoff, 1990:59)

J.F.C. Fuller summarized the art of war well. The difference that distinguishes US military forces from other combat powers is its precise weapons systems and sophisticated aircraft design[2]. The differences that J.F.C. Fuller speaks of will be empirically derived using a revealed preference method called hedonics.

There is no question that the DoD has funded many efforts that support the air superiority doctrine outlined for the USAF. An appreciable amount of money has been allocated to the DoD for this purpose. As seen in Fig. 4, the real cost of aircraft has increased substantially since the mid-1940s.

[2] J.F.C. Fuller spoke also of planning, training, morale, etc., and not just technical supremacy.

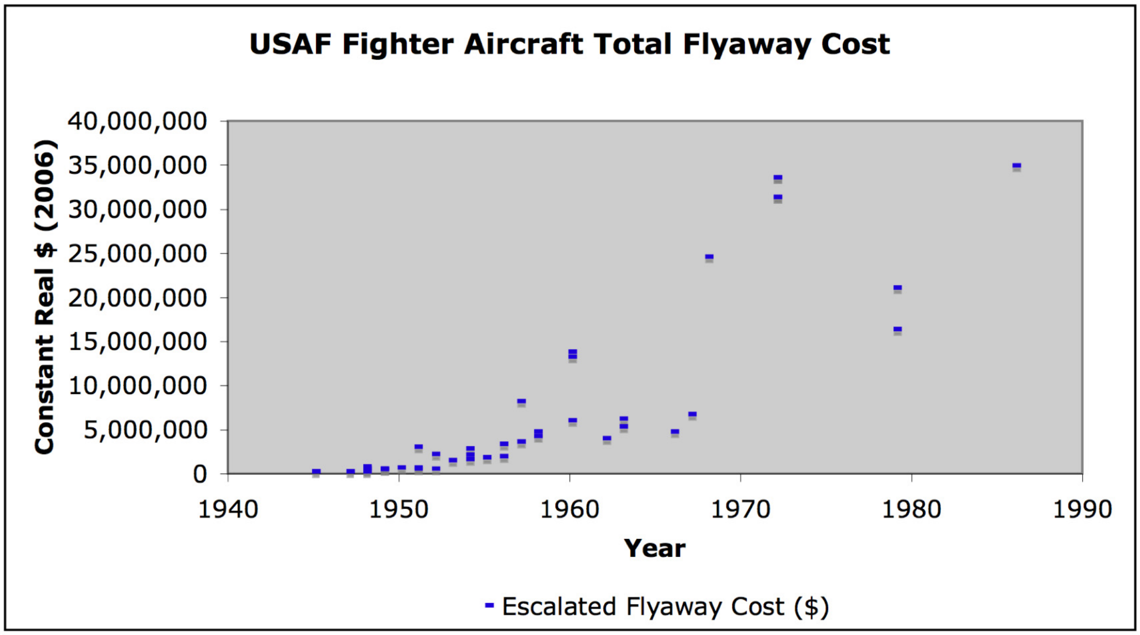

Figure 4. USAF Fighter Aircraft Total Flyaway Costs from 1946-1982

Problem Statement

Since the DoD's expenditures cost millions of dollars for a single aircraft, it is important to investigate if those dollars are well spent. The purpose of this research is twofold: to determine the US' revealed preference for air superiority and compare the characteristics of USAF fighter aircraft with those of the former USSR to evaluate the effectiveness the of the USAF fleet. As mentioned earlier, the US government has paid a monetary premium to secure and maintain control of the air, a premium that can be implicitly estimated using a non-market valuation method. This literature review will discuss elements that constitute the use of non-market valuation methods, specifically the revealed preference and hedonic pricing theories and a brief overview of other fighter aircraft studies.

Non-Market Valuation

Before the elements that constitute the use of non-market valuation methods are discussed, it is important to have a basic understanding of related concepts and terminology. The willingness of an individual or group to pay for a bundle of goods commensurate with the level of utility, or satisfaction, received from these goods is determined in two dimensions. The first dimension, "stated preference," is where we use surveys to ask people how much they are willing to pay. The aim of these surveys is to have participants openly state their willingness to pay for a good or service for which a market does not exist, like public goods[3].

The second dimension, "revealed preference," also involves choice data generated from participants, but these choices are revealed through actions and recorded by an observer (Adamowicz and others, 1997:66). Samuelson's 1938 theory of revealed preference has turned out to be foundational in non-market valuation research, where its applications are used on larger and richer sets of data describing consumer behavior (Varian, 2005:18).

[3] A public good is a good that is non-rivalrous and non-excludable. A good is non-rivalrous when its benefits fail to exhibit consumption scarcity such that once it is produced, everyone benefits without diminishing other's enjoyment. A good is non-excludable if it is not possible to prevent access to the good once it is made available to the public. A public good, such as national defense, benefits society as a whole.

The application of revealed preference theory is outlined in the table below:

Table 1. Process of Estimating Values Using Revealed-Preference Methods (Boyle, 2003: 265)

	Process of Estimating Values Using Revealed-Preference Methods
1	Identify change (s) in quantity or quality to be valued.
2	Identify population whose values are to be estimated.
3	Develop theoretical definition(s) of value(s) to be estimated.
4	Select revealed preference valuation methods.
5	Identify appropriate sources of secondary data.
6	Obtain secondary data and check the coding of the data.
7	Determine if any primary data are needed.
8	If primary data are needed, design survey instrument and collect the data.
9	Estimate model(s).
10	Derive welfare estimate(s) from estimated model(s).

Hedonic Pricing.

Hedonic pricing is one of four revealed preference valuation methods. The other methods are travel cost, defensive behavior, and cost of illness. The hedonic pricing method will be used in this study to capture quantitatively the demand for differentiated goods, in this case USAF fighter aircraft.

Publicly provided amenities such as national defense or those provided by the natural environment are frequently not priced in the market (Chattopadhyay, 2002:641). Because goods that do not have market prices themselves can often affect the prices of market goods, extensive research has been dedicated to determining their estimated implicit prices (Lesser and others, 1997:276). The differences in the characteristics of goods generate the differences in values, as well as consumers' utility functions. Sherwin Rosen is credited with the theory of hedonic prices (Rosen, 1974). A common example of hedonic theory suggests that the price of a house represents the sum of expenditures on a number of bundled housing characteristics, both structural attributes, such as the number of rooms, and less tangible characteristics including environmental quality, each of which has its own implicit price (Brasington and Hite, 2003: 59). Houses located near recreational parks tend to sell at higher prices than comparable houses elsewhere, owing to the pleasure derived from beautiful views. Similarly, houses subject to olfactory challenges created by waste water treatment plants probably sell at lower prices than comparable houses, as pleasure is derived from avoiding such disamenities (Lesser and others, 1997:276).

The hedonic pricing approach (HPA) is one way of measuring the contribution to value of the different characteristics of goods (Lesser and others, 1997:276). It has been applied to a spectrum of subjects ranging from crude oil estimation[4] to valuing clean air. Little research, however, has been done to value the benefits received from the goods or services unique to the US DoD. In a report presented to Congressional committees in 1997, the GAO recognized that "it is important that US forces be properly equipped to successfully achieve air superiority and that the effectiveness of this equipment be continually modernized" (GAO/NSIAD-99-77, 1997a:29). Though the DoD is restricted by a budget every year and is proficient in executing the fiscal dollars allocated to modernization projects, the DoD lacks the analytical support needed for overall decision-making so that resources are "applied in an efficient, economical, and effective manner" (GAO/NSIAD-99-77, 1997a:29). One tool that can be used to support recommendations concerning force capabilities and the proper allocation and execution of fiscal dollars is the HPA.

The hedonic pricing function describes the relationship between an asset's characteristics and the price at which it sells in the market. In the case of an intangible asset such as environmental quality, the hedonic pricing approach provides a reasonable approximation for the value of the good or bundle of goods in question. The function can be written in the very general form (Day and others, 2003:1):

$$P = P\,(z) \qquad (1)$$

where P is *market price* and z is *vector of characteristics*. Though the form of the hedonic pricing equation is simple, model specification, determining which characteristics belong in the model, proves challenging. It is the responsibility of the researcher to properly identify which characteristics belong in the model and to properly control for variables that may influence statistical outcomes.

Other Fighter Aircraft Studies

Few studies have been conducted concerning the benefits of fighter aircraft modernization and what the US government has been willing to pay for these benefits, but a few studies have investigated the impact of technological advances inherent in fighter aircraft acquisition. Two of these studies will be discussed here.

The first study, by Leroy Spearman, discusses fighter aircraft trends. He examines fighter aircraft "in terms of performance, mission capability, effectiveness, and cost" for the USAF, US Navy, and in some cases the Union of Soviet Socialist Republics (USSR) (Spearman, 1984:1). Spearman found that, "the trends in US fighter/attack aircraft procurement and flyaway cost from 1968 to 1982 shows a decrease in quantity and cost immediately following Vietnam, but, since the early 1970's the quantity of fighter/attack aircraft accepted has been more or less constant while the flyaway cost has

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[4] See Wang (2003) for an article on the hedonic analysis of crude oil.

risen significantly" (Spearman, 1984:6). The largest cost drivers for fighter aircraft were found to be the airframe and propulsion system. He noticed that there was an "increase in percent cost devoted to avionics—becoming about the same as that for propulsion " after the 1960's (Spearman, 1984:6). When comparing US fighters to those of the USSR, he found that US operational fighters were superior. Also, he commented that USSR fighter aircraft tended to be more agile while those of the US were designed for increased endurance.

The second study written by George Morehead in September 1973 applied a performance cost estimating relationship (CER) to the study of technological change in Navy fighter aircraft. He stated, "Since the optimal use of resources applies to both maximization of output and minimization of cost associated problems, the Department of Defense, and the Navy in particular, have become increasingly aware of the problems associated with a changing technology and its effect on resource allocation" (Morehead, 1973: 8). Morehead attempted to understand the effects of technological change by developing "a performance cost estimating relationship (CER) which when used in conjunction with hedonic price index theory, measures technological change in the form of a quality change index. This index is then used to adjust an index of observed price changes, the result of which is a true price index" (Morehead, 1973: 52). This true price index was adjusted for quality change in the performance characteristics mission speed and payload (Morehead, 1973: 52). He then applied "the associated theory to the analysis of price change in Navy fighter aircraft procured over a period of 1951 to 1961" (Morehead, 1973:52). The results of his analysis showed that while procurement costs have increased significantly, so has fighter aircraft quality. His results also indicate "new technology gives improved performance characteristics at lower costs than old technology" (Morehead, 1973: 53).

Rational Public

> An extensive literature has developed regarding the relationship between public opinion and foreign policy, with much of the research coming out of and/or focusing on American public opinion. The general consensus of the post-World War II period regarding the relationship between public opinion and foreign policy is referred to as the "Almond-Lippmann" consensus. This consensus view characterized public opinion as volatile and incoherent and, as a result, having little impact on policy outputs[5]. (Carriere and others, 1999)

New theories have surfaced in recent years that have led some economists to reject the "Almond-Lippmann" consensus[6], "which implied public attitudes were dangerously erratic, and have moved in varying degrees toward a view of public opinion as rational" (Knopf, 1998:545). The classical view of public opinion concerning military spending would suggest that the public reacts slowly and then overacts when faced with foreign threats. It is believed that this is because the public does not have a good grasp of what occurs in the larger world scheme.

The study by Jeffrey Knopf was supportive of the emerging revisionist view, that the public could react timely and rationally when confronted with some kind of foreign policy change. Regardless of whether the public is rational or not, the public may influence US government decisions. As such, it is important to recognize that the government ultimately behaves in such a way that is respectful of American ideals, ensuring safety for its people. In this study, the price paid for USAF fighter aircraft by the DoD reveals the preferences of the American public concerning the assurance of air

[5] For more discussion concerning the "Almond-Lippmann" consensus, the reader may refer to Almond (1950), Lippmann (1955), Cohen (1973), Morgenthau (1973).

superiority. Though the Soviet Union, thought to be the United States' greatest Air Force threat, was disbanded more than a decade ago, the DoD has continued its efforts to advance aircraft war-fighting technologies. It is assumed that the US public favors military spending despite the lack of a visible Air Force threat.

In summary, non-market valuation methods provide inference for the demand for goods not exchanged in a market. National defense in general, and air superiority in particular, are just these types of non-market goods.

Since the government purchases air superiority, or a better Air Force, direct utility to those bearing the cost of the purchase, the taxpayer, can only be inferred by assuming that the role of utility maximizer falls to the government. This is a standard practice in this type of research. The following chapter extends this analytical process.

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[6] Refer to Page and Shapiro (1992), Hurwitz and Peffley (1987), Wittkopf (1990), Hartley and Russett (1992), Bartels (1991, Hinckley (1992) for further discussion concerning the rejection of the "Almond-Lippmann" consensus.

III. Models and Methodology

Typically the hedonic method is "applied to markets as varied as consumer durables (e.g., automobiles and computers), agricultural commodities, labor markets, and cultural commodities (Champ and others, 2003: 382)." This is the first stage of the hedonic method. The second stage of hedonic demand application is concerned with everything except traditional consumer durables analysis. This study will attempt to estimate the demand for air superiority in a single market for USAF fighter aircraft using a second stage approach. It will also evaluate whether or not the DoD has benefited from continually investing in aircraft technology innovation. The aircraft used in the analysis range from technologies as old as the F-80 to the newly equipped F-117A.

The first step in estimating the hedonic price function is to define the value to be estimated. This is simply the US government's willingness to pay for aircraft technology supportive of USAF air superiority doctrine.

The second step is to collect data on aircraft value. When applying the hedonic method to housing, sales price is often the preferred measure of value. Similarly, fighter aircraft have a sales price. These prices are normally represented in two ways: average unit and flyaway cost.

The Defense Acquisition Guidebook defines average unit cost as the total of all acquisition-related appropriations divided by the total quantity of fully configured end items and any other cost objectives established by the milestone decision authority. If system operating and support costs are included, they are normally expressed as annual operating and support costs per deployable unit (e.g., squadron or battalion) or individual system (e.g., ship), as appropriate.

Alternatively, AF Instruction (AFI) 65-503 defines the average unit flyaway cost (equivalent to rollaway and sailaway) as those costs which relate to the production of a usable end-item of military hardware. The following items are included in unit flyaway cost under Appropriation 3010 (Aircraft Procurement): airframe; propulsion; electronics; avionics; engineering change orders (ECOs); government furnished equipment (GFE); first destination transportation (unless a separate line item); system and program management (SE/PM) if funded by Appropriate 3010; warranties; recurring costs; nonrecurring costs; and advance buy costs. Unit flyaway costs does not include: research, development, test and evaluation (RDT&E) expenditures (Appropriation 3600); weapons and armaments (except if part of the airframe); peculiar ground support equipment; peculiar test equipment; technical data; and initial and replenishment spares.

In this study, unit flyaway cost is used to represent fighter aircraft value. The reason for using this cost is because it is important that any comparisons made between aircraft solely relate to the cost of the aircraft and not any support costs that may be tied to each weapon system. These flyaway costs were obtained from several sources, such as Jane's Defense and aircraft encyclopedias covering both US and Russian airframes.

The third step in estimating the hedonic price function is to choose an appropriate functional form. The method for choosing the dependent and independent variables are discussed in this section. The dependent variable as mentioned earlier is unit flyaway costs for USAF and Soviet fighter aircraft between 1946-1982. The methodologies for choosing the independent variables are similar to those in a study for the Naval Postgraduate School by Robert Morehead in 1973.

Like those of Morehead's study, descriptive aircraft parameters fall into two categories. "The first is the group of physical characteristics which describe the aircraft (Morehead, 1973: 24)." These characteristics are load weight and thrust. The second set of characteristics deal with aircraft performance. Examples include maximum speed, service ceiling, and range. Definitions concerning both physical and performance characteristics will be briefly discussed here. Load weight was calculated by subtracting the empty and fuel weights of an aircraft from the maximum weight. The result of this simple calculation provides a variable that represents the payload weight an airframe is able hold. Thrust refers to force exerted by the engine to propel the aircraft forward. Maximum speed is simply the fastest speed an aircraft can travel, given level flight. Service ceiling is defined as the highest altitude in which a plane can maintain a 100ft/min rate of climb. Range is the area where an aircraft operates and has power or control before running out of fuel. Though data concerning the physical and performance characteristics for US fighter aircraft were plentiful, models in this study were limited by incomplete reports concerning some Soviet aircraft. When possible this study attempted to use complete sets of data for each aircraft.

Once the data was collected, the database was normalized. Cost data adjustments were necessary to account for the effects of inflation and inconsistencies in items included in the flyaway costs as published in the *Encyclopedia of U.S. Air Force Aircraft and Missile Systems*, *Volume I*. Other adjustments were made to the physical and performance characteristics due to unit inconsistencies, mainly metric to English conversions such as kg to lb.

Now that the database was normalized, the analyst is able to derive mathematical relationships. In this study a multiple regression model was used in two instances. In the first model, US aircraft were analyzed. Only 43 data points were used in this analysis. Two dummy variables were included in the normalized database. A potential stealth dummy variable was added to the database such that the F-117A was the only aircraft exhibiting stealth capability. A dummy variable for integrated circuits was also used in this analysis. Advancements in integrated circuit technology are divided into two categories: integrated circuits and large-scale integrated circuits. Integrated circuits were used from 1960 to 1978 while very large-scale integrated circuit usage dates from 1979 to present day aircraft. This dummy variable was used to approximate technological innovation regarding avionics packages found on fighter aircraft.

The first model evaluates flyaway costs as the dependent variable versus thrust, service ceiling, range, integrated circuits, and large-scale integrated circuits as independent variables.

Originally the model took on a linear functional form:

$$P = \alpha_0 + \beta_1 x_1 + \beta_2 x_2 + \beta_3 x_3 + \beta_4 x_4 + \beta_5 x_5 + e \qquad (2)$$

where P is *flyaway cost*, α_0 is the *intercept*, x_1 is *thrust*, x_2 is *service ceiling*, x_3 is *range*, x_4 is *integrated circuits*, x_5 is *large-scale integrated circuits*, and e is *stochastic error*. It was expected that each of these independent variables highly influence aircraft costs.

Literature suggests that in choosing a functional form using the hedonic method that linear functions are not usually appropriate. Semi-log functional forms are often used instead (Champ and others, 2003: 339). Furthermore, "the semi-log allows for incremental changes in characteristics to have a constant effect on the percentage change in price and non-linear relationship on the price level (Champ and others, 2003:357)." As such a non-linear regression model was used:

$$\hat{P} = \alpha_0 + \beta_1 x_1 + \beta_2 x_2 + \beta_3 x_3 + \beta_4 x_4 + \beta_5 x_5 + e \tag{3}$$

where $\hat{P}$ is *ln(flyaway cost)*, α_0 is the *intercept*, x_1 is *thrust*, x_2 is *service ceiling*, x_3 is *range*, x_4 is *integrated circuits*, x_5 is *large-scale integrated circuits*, and e is *stochastic error*. Another non-linear model was used:

A second database was created to compare US and Soviet fighter aircraft characteristics. Like the original database, physical and performance data for each aircraft were compiled. Only here US aircraft were matched with an enemy aircraft. The aircraft matches were based on two principles. First, historical literature was used to support the matching of aircraft. For example, certain airframes like F-15E were designed to combat the threat fighter Su-34. Not all Soviet fighter aircraft were included in the database. The main reason for this is that some Soviet planes were not designed to combat USAF planes. In some instances, the Soviets designed planes to combat Naval aircraft such as the TU-28P whose comparable US aircraft was the F-14. In other instances, the Soviet aircraft never became operational. An example is the Yak-23. US intelligence was able to evaluate the Yak-23 after acquiring one airframe. Shortly after this incidence, Yak-23s were withdrawn from production lines. Second, aircraft matches were made with aircraft variants that were fielded approximately in the same time frame. Each US variant was matched with a Soviet plane that had similar mission objectives, characteristics, and was fielded either shortly before or after the combatant plane. Once all the Soviet fighter aircraft were matched with a US equivalent, calculations were done for each variable. For example, in the case of the F-104A versus the MiG-21, the thrust variable was calculated:

$$T = UT - ST \tag{4}$$

where *T* is *engine thrust*, *UT* is *US fighter aircraft thrust*, and *ST* is *Soviet Union fighter aircraft thrust*. Similar calculations were done for each matched aircraft and variable category. This database was used to conduct another linear regression. The functional form for this regression model is as follows:

$$\hat{P} = \alpha_0 + \beta_1 x_1 + \beta_2 x_2 + \beta_3 x_3 + \beta_4 x_4 + \beta_5 x_5 + e \tag{5}$$

where $\hat{P}$ is *ln(flyaway cost)*, α_0 is the *intercept*, x_1 is *thrust*, x_2 is *load weight*, x_3 is *maximum speed*, x_4 is *service ceiling*, x_5 is *range*, and *e* is *stochastic error*. The analysis for all these regression models will be discussed in the next section. The databases, matches, and unit conversions can be found in Appendix B.

IV. Model Evaluation and Analysis

Two models were used in this study[7]. The first model was restricted to USAF fighter aircraft and their corresponding physical and performance characteristics. A multiple regression estimation method was used to estimate the coefficients of the independent variables in the following general non-linear equation:

$$\hat{P} = \alpha_0 + \beta_1 x_1 + \beta_2 x_2 + \beta_3 x_3 + \beta_4 x_4 + \beta_5 x_5 + e \qquad (3)$$

where $\hat{P}$ is *ln(flyaway cost)*, α_0 is the *intercept*, x_1 is *thrust*, x_2 is *service ceiling*, x_3 is *range*, x_4 is *integrated circuits*, x_5 is *large-scale integrated circuits*, and e is *stochastic error*. Summary statistics of selected variables appear in Table 2:

Table 2. US Fighter Aircraft Summary Statistics

	Mean	Max	Min	Std. Dev.
Engine Thrust (lbf)	13286.74	24500	1600	7986.331
Service Ceiling (ft)	49469.3	64795	36800	6700.3
Range (miles)	1832.07	3178	540	581.2592
Integrated Circuits	0.4418605	1	0	0.6287677
Large-Scale Integrated Circuits	0.1627907	1	0	0.3735437

A linear functional form for the hedonic price function is not usually appropriate. Therefore, a semi-log functional form was used for ease in interpreting coefficients. Here β indicates a percentage change in flyaway cost due to x_i.

The regression estimates are contained in Table 3.

[7] The independence of the right hand side variables used in both models may not be clear, possibly due to signaling between both countries or human intelligence providing information about threat aircraft.

Table 3. US Fighter Aircraft Regression Estimates

	Coefficient	Robust Std. Error	t-Statistic	Prob.
Intercept	10.06084	0.5747992	17.50	0.000
Engine Thrust	0.0001013	0.000019	5.32	0.000
Service Ceiling	0.0000465	0.0000124	3.74	0.001
Range	0.0005569	0.0001922	2.90	0.006
Integrated Circuits	0.1920676	0.2556311	0.75	0.457
Large Scale Integrated Circuits	0.7378995	0.3189841	2.31	0.026
R-squared	0.9121			
F-statistic	113.45			
Prob > F	0.0000			

This model was regressed using Huber-White estimators to obtain better tests and confidence intervals to correct for asymptotic standard errors (Maas and Hox, 2004:129).

There are several assumptions made in evaluating regression model relationships. The first is ensuring the model is specified correctly. An omission of relevant independent variables or inclusion of irrelevant variables can create bias. Economic theory should be available to defend the use of explanatory variables in the model. For the purposes of this study, all physical and performance characteristics are measurable items regularly found in literature concerning fighter aircraft. The RESET test was used to identify if an explanatory variable may have been omitted due to model misspecification (Ramsey, 1979). The RESET test resulted in failure to reject the null hypothesis that the model is specified correctly.

The second assumption that many researchers believe must be satisfied is the assumption that errors are normally, identically, and independently distributed. Several residual plots were investigated to ensure this assumption was met. These residual plots can be found in the appendix. Also, the Shapiro-Wilk test for normality resulted in an insignificant p-value such that the null hypothesis could not be rejected. Therefore, there is no significant evidence to conclude that the residuals are not normally distributed.

A third assumption is the homogeneity of error variance. Any possible heteroskedasticity was detected using a graphical method where residuals were plotted against the fitted values. The residual plot indicated that the assumption could be accepted. Furthermore, the Breusch-Pagan test resulted in a p-value that was not significant. Thus, there is no significant evidence to conclude that the variance of the residuals is not homogeneous.

The fourth and last assumption that must be satisfied is that predictors are not collinear. Multicollinearity issues can cause problems with coefficient estimates. More specifically, regression model estimates of the coefficients may be unstable and their standard errors inflated. The variance inflation factor (VIF) test was used to detect multicollinearity issues. The VIF table can be found in the appendix. Typically a VIF value greater than 10 can merit further investigation. The VIF values did not prove worrisome. Additionally, the Hausman test showed no signs of endogeneity issues. This is also often interpreted as a specification test, pointing to robustness in the estimates. Now that all the assumptions associated with the multiple regression estimation model has been satisfied, the researcher can conduct a statistical evaluation.

According to the F-statistic, the overall model is significant. The coefficient of determination, R^2, is 0.9121, which means that the resulting model explains approximately 91 percent of the variability in flyaway costs for 43 USAF fighter aircraft. The intercept and four variables used in the model were statistically significant. The explanatory variable coefficients were all positively related to flyaway costs. For example, a unit increase in range would yield a 0.06 percent increase in flyaway costs. The percentage change in flyaway cost due to large-scale integrated circuits is the highest coefficient value overall[8]. This indicates that it is the greatest cost driver found in USAF fighter aircraft. It is not surprising that the dummy variable used to represent advancement in avionics had the greatest impact on the flyaway cost for USAF fighter aircraft. In a study done by M.L. Spearman in 1984 concerning fighter aircraft trends, he stated "the airframe is shown to be the largest cost factor, averaging about 60 percent of the total flyaway costs over the years. The second largest cost contributor is generally the propulsion system." He later states that avionics was becoming a large cost factor that would match that would later match that of propulsion. It seems many changes have come about since the dawn of integrated circuit technology in the 1960's such that integrated circuitry is the greatest contributing cost factor, far surpassing the impact of propulsion technology.

The second model compared USAF and Soviet fighter aircraft physical and performance characteristics. For example, the SU-30MKI was designed to combat the F-15E. The F-15E took its first flight in 1986, followed almost a decade later by the SU-30 MKI, taking its first flight in 1994. Both aircraft were designed as dual-seater, multi-role tactical fighters. Though the F-15E is faster and has greater range, the SU-30MKI exhibits a more powerful propulsion system, heavier weapons payload capability, and higher service ceiling. The remaining USAF and Soviet fighter aircraft were matched in a similar manner.

[8] The coefficient for this ordinal variable is difficult to interpret but still yields the highest value indicating it is the largest cost factor in the model.

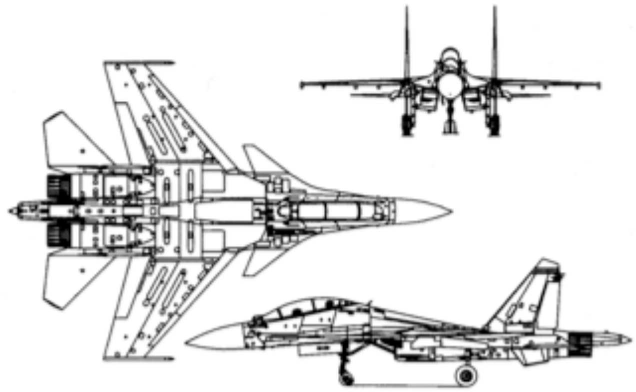

Figure 5. SU-30MKI Line Drawing

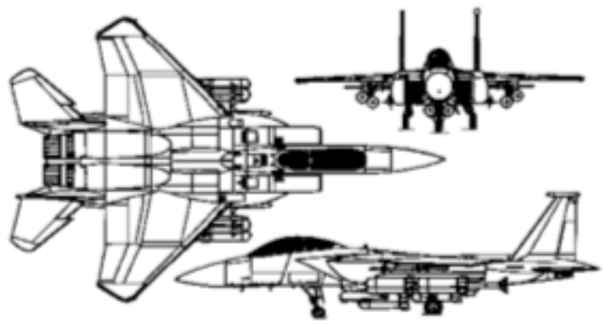

Figure 6. F-15E Line Drawing

In this model the general form for the equation is as follows:

$$\hat{P} = \alpha_0 + \beta_1 x_1 + \beta_2 x_2 + \beta_3 x_3 + \beta_4 x_4 + \beta_5 x_5 + e \quad (5)$$

where $\hat{P}$ is *ln(flyaway cost),* α_0 is the *intercept*, x_1 is *thrust*, x_2 is *load weight*, x_3 is *maximum speed*, x_4 is *service ceiling*, x_5 is *range,* and e is *stochastic error*. Summary statistics of these selected variables appear in Table 4.

Table 4. US versus USSR Fighter Aircraft Summary Statistics

	Mean	Max	Min	Std. Dev.
Δ Engine Thrust	572.2296	8763.69	-7085	3852.689
Δ Payload Weight	2331.237	17343	-17658.17	8917.554
Δ Maximum Speed	33.2288	620	-742.41	317.7751
Δ Service Ceiling	-3868.4	8800	-19300	6180.04
Δ Range	709.3576	1628	-387	578.0983

The regression estimates for this model are contained in Table 5.

Table 5. US versus USSR Fighter Aircraft Regression Estimates

	Coefficient	Robust Std. Error	t-Statistic	Prob.
Intercept	14.4557	0.5807653	24.89	0.000
Engine Thrust	-0.0000776	0.0000769	-1.01	0.325
Payload Weight	-0.000035	0.0000306	-1.14	0.268
Maximum Speed	0.0011686	0.0005476	2.13	0.046
Service Ceiling	-0.0000996	0.0000438	-2.28	0.035
Range	0.0007369	0.0005638	1.31	0.207
R-squared	0.2913			
F-statistic	4.23			
Prob > F	0.0094			

This model was also regressed using Huber-White estimators.

Again, the Ramsey RESET test was done to ensure relevant explanatory variables were not excluded and irrelevant explanatory variables were not included in the model. The results of the RESET test showed that the null hypothesis could not be rejected. Therefore there is not enough evidence to suggest the model was subject to omitted variable bias.

The other assumptions made in evaluating the regression model relationships are that errors are normally, identically, and independently distributed; homogeneous error variance; and that predictors are not collinear. It may be difficult to meet these assumptions given a rather small sample size of 25 observations. Nevertheless, these assumptions must be satisfied before the researcher can interpret coefficients or conduct further analysis. The residual plots were investigated to ensure the errors were normally, identically, and independently distributed. By means of visual inspection it appears the residual plots support the normality assumption. The Shapiro-Wilk test also supports this conclusion, as the null hypothesis could not be rejected. A plot of fitted values versus residuals allowed for a visual inspection of possible heteroskedasticity. The Breusch-Pagan test resulted in a p-value that was not significant indicating there is not enough evidence to reject the null hypothesis. The VIF test was then conducted to check for possible multicollinearity issues. All VIF values were less than two indicating that there is no multicollinearity problems associated with this set of variables. The final test checked for endogenity. The Hausman test showed that endogenity and misspecification were not issues.

Now that all the assumptions were satisfied, analysis was conducted on this comparative model. The overall model is statistically significant such that it explains approximately 29 percent of the variability in flyaway costs of USAF versus Soviet fighter aircraft. Along with the intercept -- maximum speed and service ceiling variables were statistically significant. However, the service ceiling variable coefficient was found unexpectedly negative. This may be due to the fact that Soviet fighter aircraft had significantly higher service ceiling thresholds while USAF fighter aircraft were able to maintain level flight acceleration better than their Soviet counterparts. This seems to be contrary to some of Spearman's findings. He claimed that US operational fighters were superior to those of the USSR. This may not be the case. He also found that USSR fighter aircraft were faster than comparable US aircraft. This analysis shows that US aircraft can achieve greater speeds.

In any case, it seems all the coefficients were rather small. As such, it is possible that USAF fighter aircraft are not necessarily that much better than Soviet aircraft strictly in terms of physical and performance characteristics. In looking strictly at the summary statistics it appears that US fighter aircraft are better on average in regards to these physical and performance characteristics. However, the large standard deviations associated with these characteristics merit further investigation. Several t-Tests were conducted to see if there were any differences between aircraft based on these characteristics. The results are found in Table 6 below.

Table 6. US versus USSR Fighter Two-Tailed t-Test Results

	Thrust	Payload Weight	Maximum Speed	Service Ceiling	Range
t-Test Statistic	0.2502	0.8034	0.2689	-1.7563	9.2832
Lower Critical Value	-2.0106	-2.0167	-2.0106	-2.0106	-2.0106
Upper Critical Value	2.0106	2.0167	2.0106	2.0106	2.0106
p-Value	0.8035	0.4262	0.7891	0.0854	0.0000

The results of the t-Tests showed that on average there is no difference in regards to thrust, payload weight, and maximum speed when comparing US and USSR fighter aircraft. However, based on additional one-tailed t-Tests, the results show that USSR fighter aircraft can attain higher service ceilings while those of the US exhibit greater range on average. The results for the one-tailed t-Tests are found in Table 7.

Table 7. US versus USSR Fighter One Tailed t-Test Results

	Service Ceiling	Range
t-Test Statistic	-1.756309872	3.852368926
Critical Value	-1.677224197	1.677224197
p-Value	0.042707066	0.000173277

These results suggest that the US government is paying for physical and performance characteristics but not necessarily paying to have relative advantage over the threat. If USAF fighter aircraft are not relatively superior to those procured by the former USSR strictly by means of physical and performance characteristics, there must be some other unknown quality that has not been captured. Identifying this unknown quality that separates USAF fighter aircraft from rivals is a possible area for further research.

V. Conclusion

As the United States continues to assess emerging threats and forge appropriate responses, understanding the nations' historical demand for air superiority is critical. This study attempted to answer two questions to assist decision makers in planning for the future of the USAF fighter aircraft fleet: (1) What is the US government's revealed preference for ensuring air dominance? (2) Has the US government purchased fighter aircraft that are inferior, superior, or comparable to threat technologies, namely the former Soviet Union?

In comparing strictly US aircraft, my analysis suggest that the US government has been willing to pay a great deal for aircraft innovation in the areas of avionics, higher service ceiling, greater range, and superior propulsion systems. The US appears to find such advancements necessary as a new, fifth generation of fighter aircraft are currently tested and fielded.

However, when historically comparing US fighter aircraft against those of the former Soviet Union, I find that expenditures are not strongly linked to relative technological superiority. Simple comparative analysis of the data reveal that the US government is paying for characteristics that are absolute and not to have a relative advantage over the threat. This research suggests that based on the characteristics analyzed, there is not much difference between US and USSR fighter aircraft. However, it could be that the USAF fighter aircraft have better avionics packages or more precise missiles and bombs. These are areas that merit further investigation.

These findings are important primarily for what they do not find, rather than what they do find. Since the US government is not displaying a revealed preference for a fighter aircraft relatively more advanced than the dominant foe – at least within the context of these measurable characteristics – then our historical air superiority is based on some other factor. These results suggest that there is some embedded characteristic in fighter aircraft technology, some unobservable schema that generates air superiority that the US has enjoyed for over fifty years. If, by chance, through process of elimination, it is determined that none of the physical and performance characteristics associated with fighter aircraft matter, then there is evidence to suggest that it is the human factor that makes the difference.

It is likely that the embedded characteristics of fighter aircraft that generates air superiority supports in the investment of human capital or air and ground crews, and their command and control. This could be in the form of better pilot and navigator training or maintenance crews, or something that benefits command and control. This research lays aside the mistaken, but widely shared belief that our aircraft are demonstrably better than those of our enemy, at least in respect to the characteristics outlined in this study. If the US government is not paying for a better AF by means of a fleet of fighter aircraft with physical and performance characteristics that surpass those of combatants, there are some qualities the government displays a revealed preference for that remain unknown and should be identified.

It could be that Spearman is correct in his assertion that the US has been paying for fighter aircraft to endure decades of service. His claim has yet to be empirically justified. I recommend follow-on empirical research that identifies human factor differences between US and their enemy air and ground crews, the relative frequency and intensity of training, the effectiveness of joint and combined training on US forces and the role ground training and pilot selection plays in overall air superiority. These are just a few areas that warrant further research. However, the most clear expression of the role of non-technical factors in air superiority is provided by former Under Secretary of

Defense for Research and Engineering, Dr. Malcolm Currie:

> In this increasingly competitive, often hostile and rapidly changing world, Americans seem to have only one real choice. Clearly our national well-being cannot be based on unlimited raw materials or on unlimited manpower and cheap labor. Rather it must be based on our ability to multiply and enhance the limited natural and human resources we do have. Technology thus appears to offer us our place in the sun – the means to insure our security and economic vitality. (Westenhoff, 1990:85)

His assessment of the current war-fighting environment is correct. The US is faced with the challenge of continuing operations given limited resources and manpower. In this age technology may be only a piece of what is required to buy a better Air Force.

Appendix A: Normality and Heteroskedasticity Plots

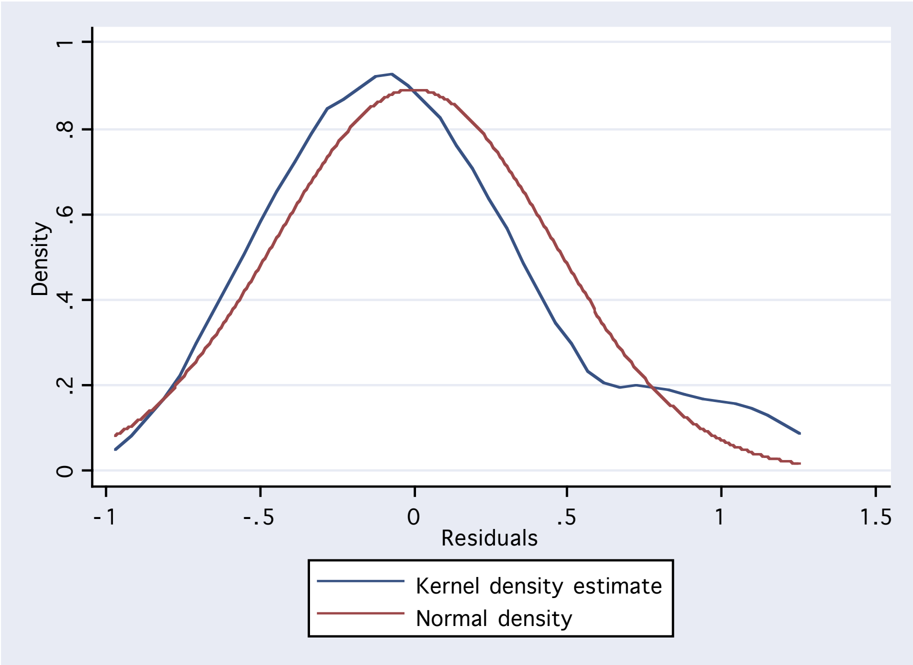

Figure 7. Model 1 Normality Residual Plot

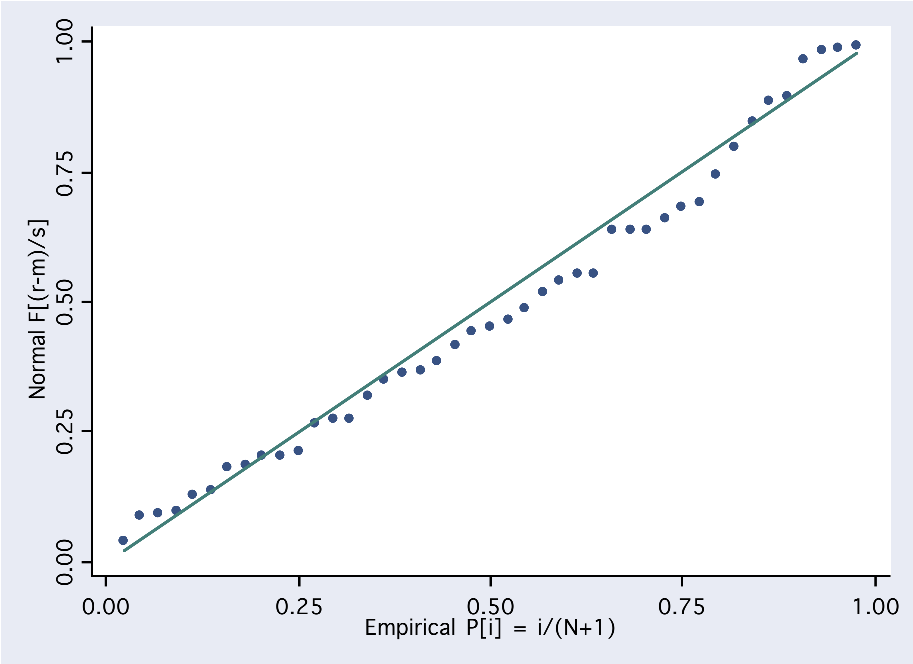

Figure 8. Model 1 Residual Standardized Normal Probability Plot

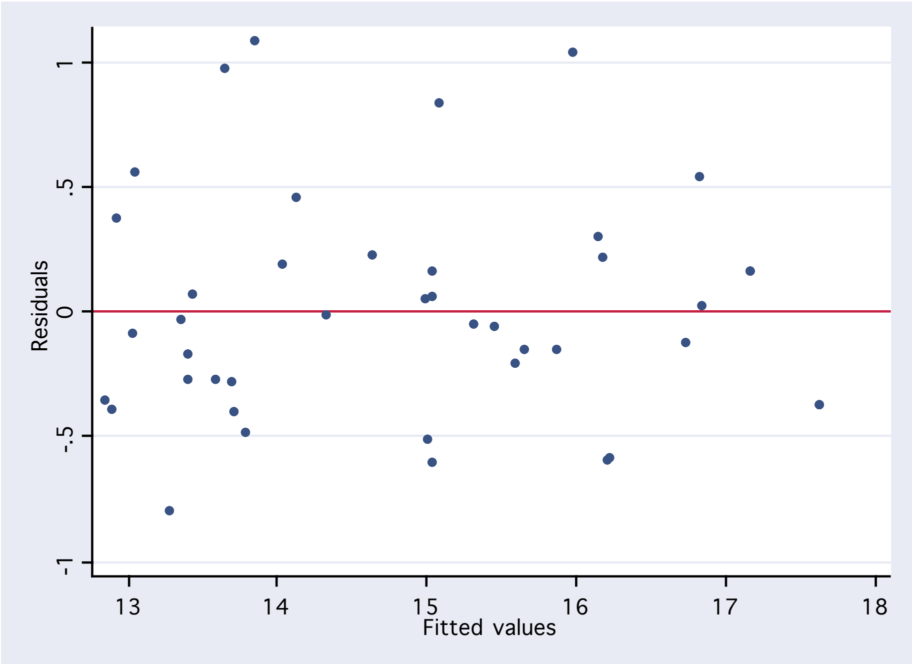

Figure 9. Model 1 Heteroskedasticity Plot

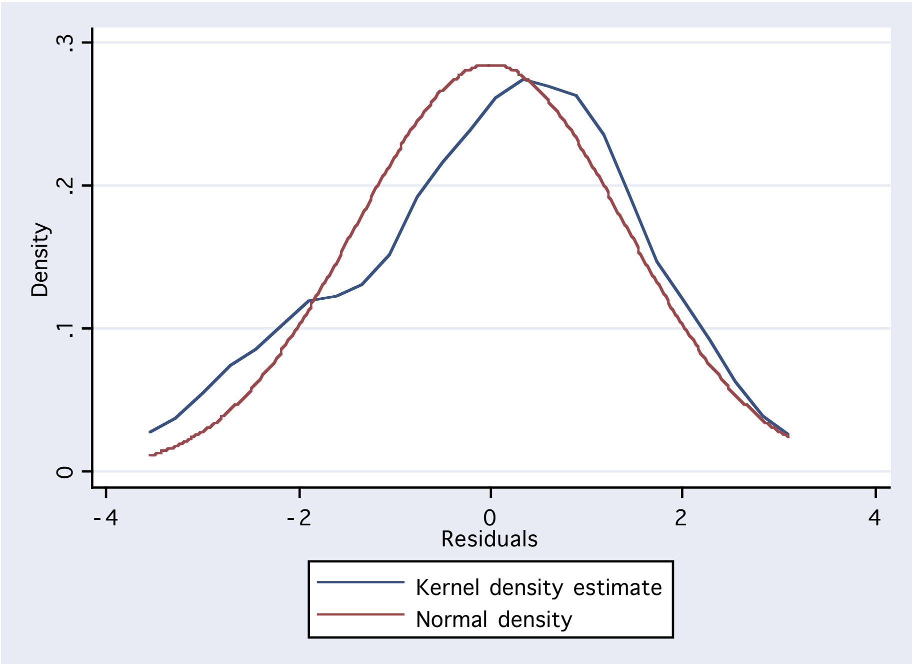

Figure 10. Model 2 Normality Residual Plot

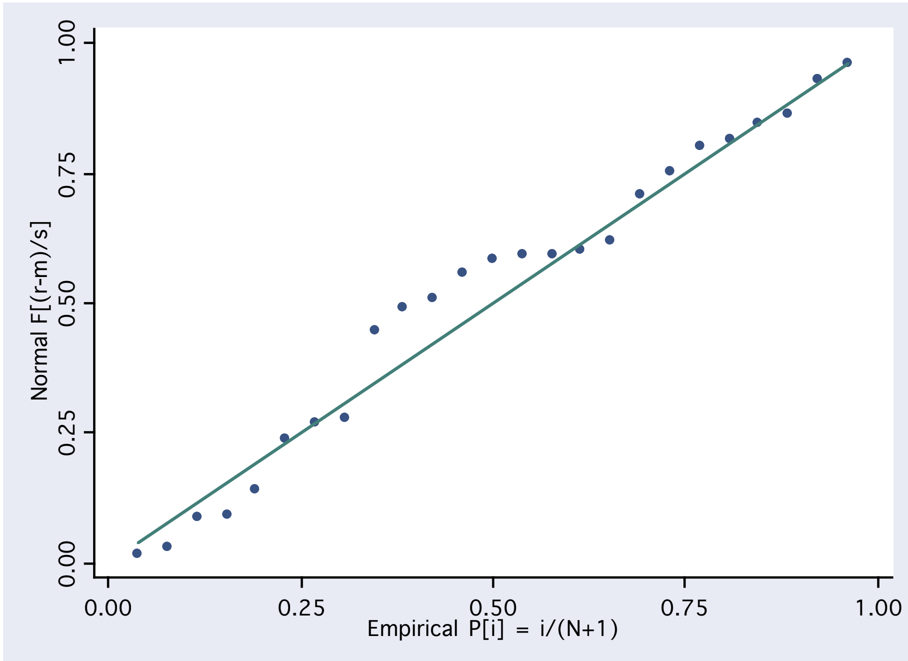

Figure 11. Model 2 Residual Standardized Normal Probability Plot

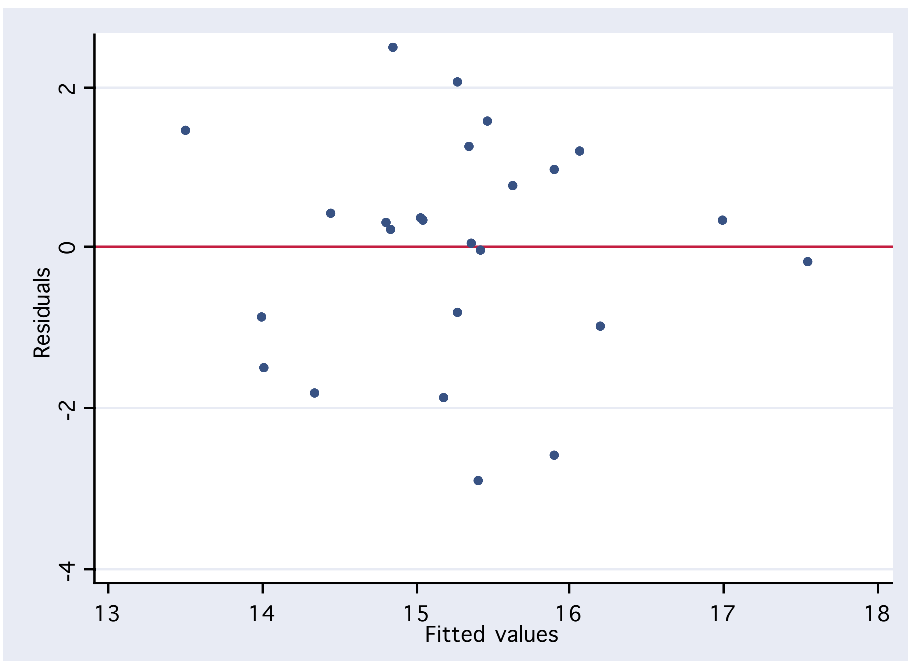

Figure 12. Model 2 Heteroskedasticity Plot

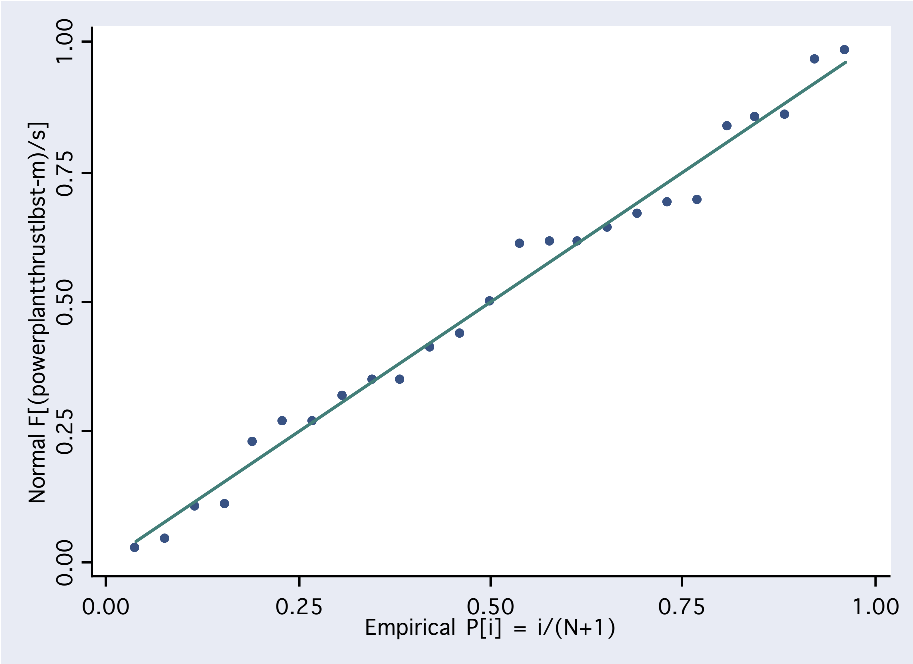

Figure 13. Engine Thrust Standardized Normal Probability Plot

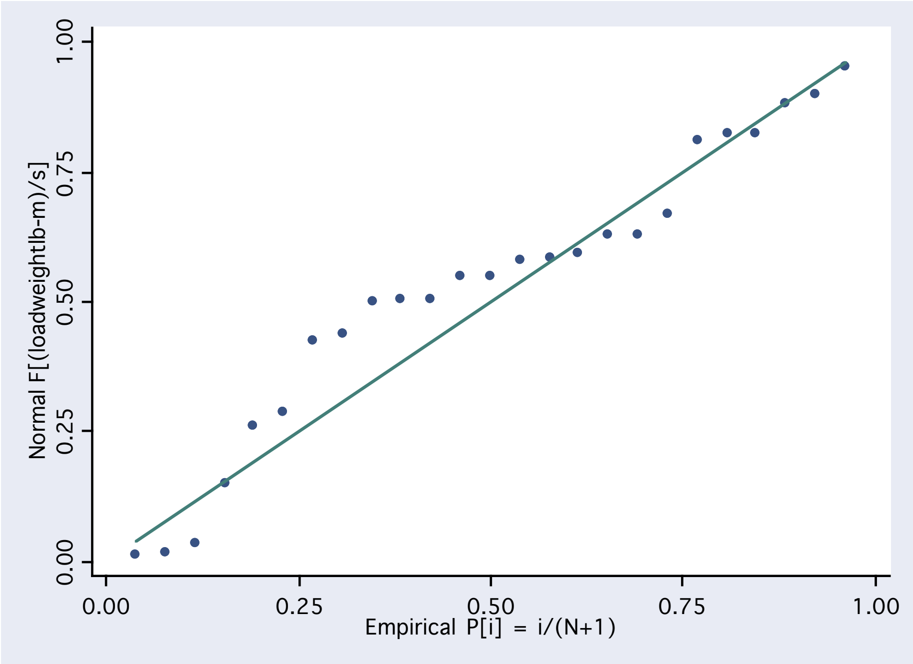

Figure 14. Payload Weight Standardized Normal Probability Plot

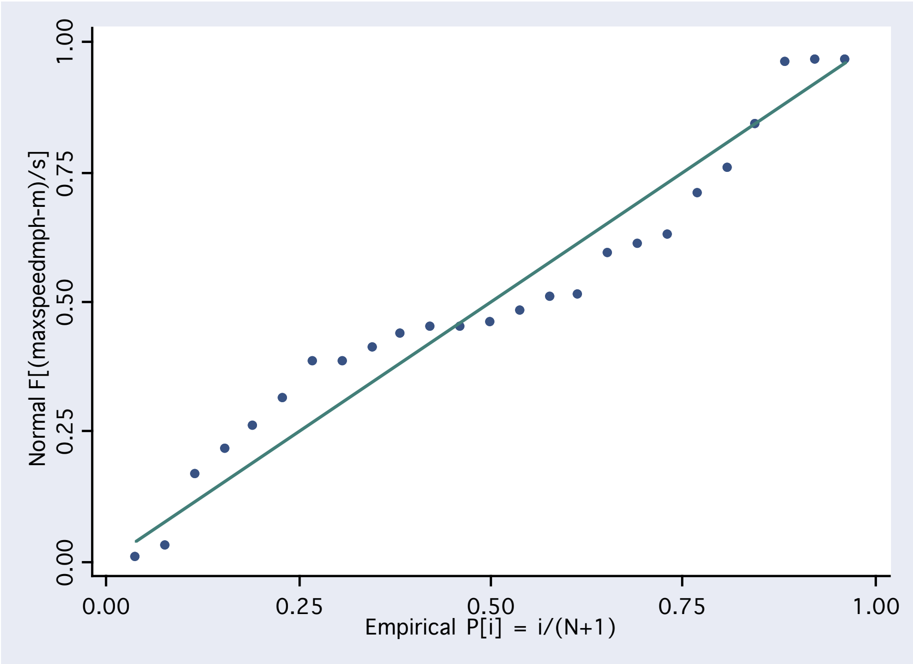

Figure 15. Maximum Speed Standardized Normal Probability Plot

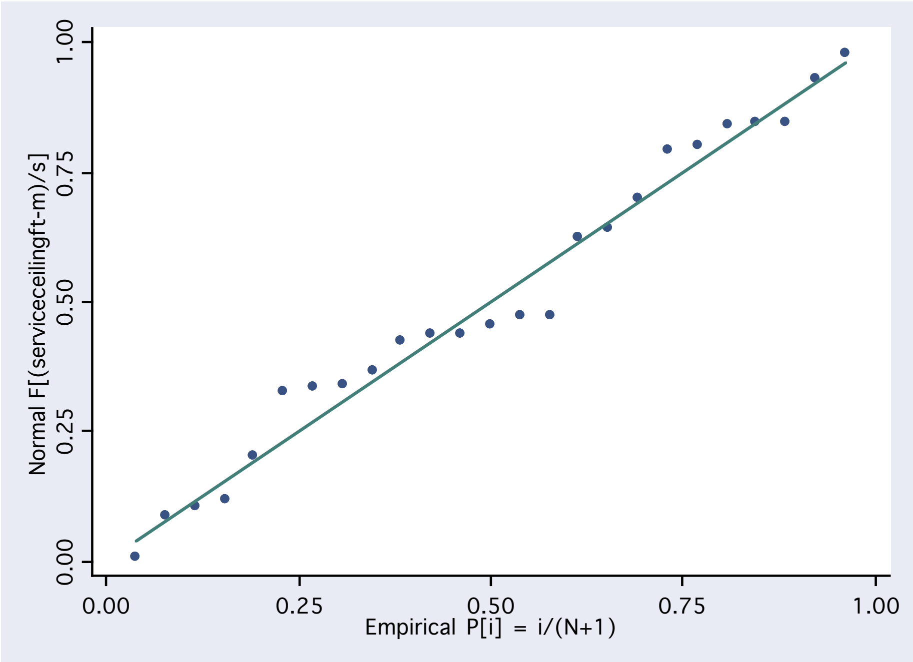

Figure 16. Service Ceiling Standardized Normal Probability Plot

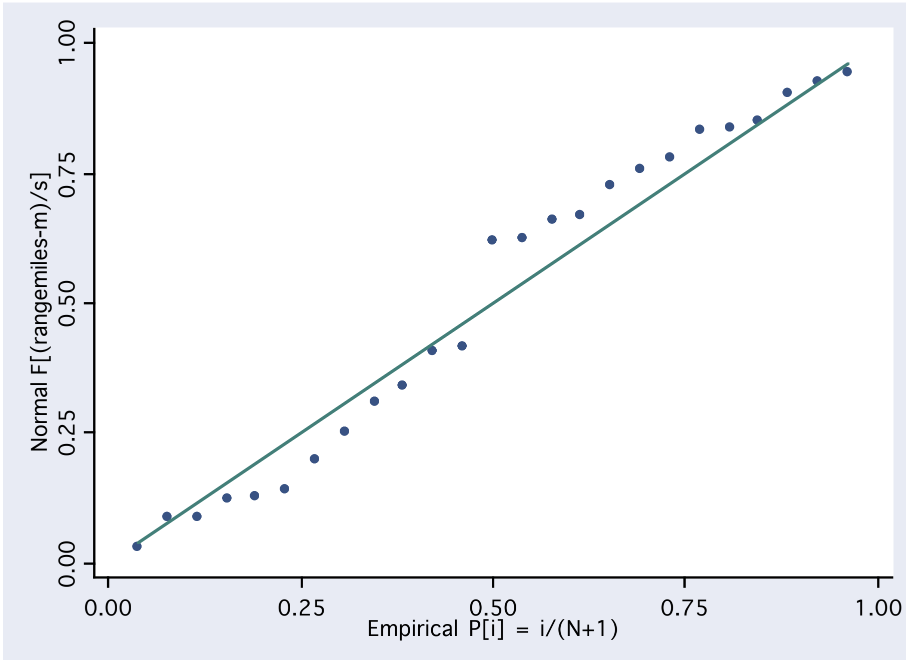

Figure 17. Range Standardized Normal Probability Plot

Appendix B: Databases

Table 8. Model 1 Database

popularname	model	year	powerplantthrustlbst	loadweightlb	maxspeedmph	serviceceilingft	rangemiles	lnflyawaycost	ic	lsic
Shooting Star	F-80 A	1945	4000	5855	558	45000	540	12.50191	0	0
Shooting Star	F-80 B	1947	4500	7069	577	36800	1210	12.50191	0	0
Shooting Star	F-80 C	1948	4600	7861	580	42750	1380	12.48552	0	0
Twin-Mustang	F-82 E	1948	1600	8754	465	40000	2708	13.31939	0	0
Twin-Mustang	F-82 F	1948	1600	8703	460	38700	2400	13.31939	0	0
Thunderjet	F-84 B	1948	3750	9365	587	40750	1282	13.60545	0	0
Thunderjet	F-84 C	1948	3750	9350	587	40600	1274	12.94321	0	0
Thunderjet	F-84 D	1949	3750	9430	587	39300	1198	13.30575	0	0
Thunderjet	F-84 E	1949	4900	10351	619	43220	2057	13.30575	0	0
Sabre	F-86 A	1949	5200	5108	679	48000	1052	13.13211	0	0
Starfire	F-94 A	1950	4600	5125	606	49750	1079	13.50147	0	0
Thunderjet	F-84 G	1951	5600	11068	622	42100	2000	13.41713	0	0
Scorpion	F-89 A/B	1951	6800	16765	642	51400	1300	14.93818	0	0
Starfire	F-94 B	1951	6000	6002	588	48000	905	13.22741	0	0
Scorpion	F-89 C	1952	7400	11219	650	50500	905	14.62914	0	0
Sabre	F-86 F	1952	5910	8392	695	48000	1615	13.30042	0	0
Starfire	F-94 C	1953	8750	10150	640	51400	1275	14.22857	0	0
Thunderstreak	F-84 F	1954	7200	10102	685	44300	2314	14.59355	0	0
Sabre	F-86 H	1954	8920	9258	692	50800	1810	14.31535	0	0
Super Sabre	F-100 A	1954	14800	9420	852	51000	1294	14.87059	0	0
Super Sabre	F-100 C	1955	16000	14287	925	49100	1954	14.44508	0	0
Delta Dagger	F-102 A	1956	16000	10411	780	53400	1492	15.03811	0	0
Super Sabre	F-100 D	1956	16000	14347	910	47700	1995	14.49486	0	0
Voodoo	F-101 A	1957	15000	18396	1005	49450	2186	15.92269	0	0
Voodoo	F-101 C	1957	15000	21343	1004	49000	2125	15.09963	0	0
Starfighter	F-104 A	1958	14800	10785	1324	64795	1585	15.38642	0	0
Starfighter	F-104 C	1958	15800	13466	1324	58000	1727	15.26125	0	0
Delta Dart	F-106 A	1960	24500	11504	1328	52700	1809	16.40335	1	0
Delta Dart	F-106 B	1960	24500	14858	1328	51450	1842	16.44502	1	0
Thunderchief	F-105 D	1960	24500	19806	1373	48500	2208	15.61659	1	0
Starfighter	F-104 G	1962	15800	13294	1328	46300	1875	15.20644	1	0
Thunderchief	F-105 F	1963	24500	23885	890	48500	2228	15.64424	1	0
Phantom II	F-4 C	1963	17000	27256	1433	56100	1926	15.49764	1	0
Phantom II	F-4 D	1966	17000	27193	1432	55850	1844	15.38642	1	0
Phantom II	F-4 E	1967	17900	28783	1464	59600	1885	15.73126	1	0
Aardvark	F-111 B	1968	18500	27283	1450	44900	3178	17.01911	1	0
Eagle	F-15 A	1972	23480	22783	1650	63350	2720	17.26103	0	1
Eagle	F-15 B	1972	23480	22783	1650	63350	2720	17.26103	0	1
Eagle	F-15 C	1972	23450	25163	1543	56440	2469	17.33026	0	1
Eagle	F-15 D	1972	23450	25163	1543	56440	2469	17.33026	0	1
Fighting Falcon	F-16 A	1979	23820	16906	1346	47435	2385	16.61343	0	1
Fighting Falcon	F-16 C	1979	23770	16509	1278	52450	2159	16.86626	0	1
Strike Eagle	F-15 E	1986	23450	43705	1875	50000	2400	17.36961	0	1

Table 9. Model 2 Database

model	lnflyawaycost	powerplantthrustlbst	loadweightlb	maxspeedmph	serviceceilingft	rangemiles
F-104A vs. MiG-21	15.39	-936.31	3385	-61	2495	1305
F-86F vs. MiG-15	13.3	-272.12	5217.46	42.56	-1900	885
F-4D vs. MiG-231	15.39	-1793.65	12908	-121	-4845	1272
F-86A vs. La-15	13.13	1693.05	2295	41	5350	322
F-80A vs. MiG-9	12.5	2236.34	2454	21	2350	40
F-100A vs. MiG-19	14.87	7628.74	4414	137	-6415	-81
F-80A vs. Yak-15	12.5	1999.24	4276	123	1200	223
F-80B vs. Yak-17	12.5	2499.24	5285.64	109	-5020	963
F-111B vs. Su-24	17.02	1639.67	-2727	620	8800	1628
F-101C vs. Yak-28P	15.1	4659	17343	254	-6000	575
F-15D vs. Su-47	17.33	4701.31	10573	-7	-4260	1539
F-104A vs. Mig-21	15.39	-936.31	3385	-61	2495	1275
F-102A vs. Su-9	15.04	-4232.4	2411	-742.41	-1600	1152
F-100C vs. Su-7	14.45	578.42	6217	210	-600	1054
F-104G vs. Su-15	15.21	-2278.77	594	-575.02	-19300	475
F-106A vs. Su-152	16.4	8763.69	900	1	-12300	896
F-15D vs. Su-27	17.33	-4155.98	10573	-7	-4260	49
F-16C vs. Su-37	16.87	-7085	-17658.17	-272	-6605	-71
F-89A/B vs. Yak-25	14.94	1696.94	10150	-38	1400	-387
F-4D vs. MiG-23	15.39	-1793.65	13734	594	-4845	92
F-15A vs. MiG-25	17.26	-1248.48	-14087	-215	-4565	1111
F-15D vs. MiG-31	17.33	2543.19	-17137	613	-11160	419
F-86F vs. MiG-17	13.3	-47.32	-3386	-16	-6500	945
F-16A vs. Mig-29	16.61	4396.9	4156	-172	-11625	585
F-15E vs. Su-30MKI	17.37	-5950	-6995	352.59	-9000	1467.94

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14. ABSTRACT
The purpose of this study was twofold: to capture the United States (US) government's revealed preference for air superiority using the hedonic pricing approach (HPA) and compare the characteristics of United States Air Force (USAF) fighter aircraft with those of the former Soviet Union to evaluate the effectiveness of the USAF fleet. The resulting analysis showed that the US government is paying for physical and performance characteristics such as engine thrust, service ceiling, range, and large scale integrated circuit technology. However, evidence suggests the government is not paying to have a relative advantage over the enemy based on the physical and performance characteristics analyzed.

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