3-11-2009

Jet Fuel Hedging Strategies for the Department of Defense Through Use of Financial Derivatives

William T. Gibson

JET FUEL HEDGING STRATEGIES FOR THE DEPARTMENT OF DEFENSE

THROUGH USE OF FINANCIAL DERIVATIVES

THESIS

William T. Gibson, Captain, USAF

AFIT/GCA/ENV/09-M04

DEPARTMENT OF THE AIR FORCE
AIR UNIVERSITY

AIR FORCE INSTITUTE OF TECHNOLOGY

Wright-Patterson Air Force Base, Ohio

AFIT/GCA/ENV/09-M04

JET FUEL HEDGING STRATEGIES FOR THE DEPARTMENT OF DEFENSE THROUGH USE OF FINANCIAL DERIVATIVES

THESIS

Presented to the Faculty

Department of Systems and Engineering Management

Graduate School of Engineering and Management

Air Force Institute of Technology

Air University

Air Education and Training Command

In Partial Fulfillment of the Requirements for the

Degree of Master of Science in Cost Analysis

William T. Gibson, BS

Captain, USAF

March 2009

AFIT/GCA/ENV/09-M04

JET FUEL HEDGING STRATEGIES FOR THE DEPARTMENT OF DEFENSE
THROUGH USE OF FINANCIAL DERIVATIVES

William T. Gibson, BS
Captain, USAF

Approved:

_______________//signed//_________________ ___11 March 09____
Todd A. Peachey, Major, USAF (Chair) date

_______________//signed//_________________ ___11 March 09____
Eric J. Unger, Lt Col, USAF (Member) date

AFIT/GCA/ENV/09-M04

Abstract

The primary purpose of this research is to assess the practicality of utilizing some of the financial derivative products available on the market today in an effort to mitigate monetary losses due to the increasing price of jet fuel, thereby increasing stability in the DOD budget. The scope of this research will focus on the use of futures and call option contracts. Domestic jet fuel expenditure data was collected for Fiscal Years 1996 to 2007 and cross-referenced with the contract process of the previously mentioned financial hedging instruments during the same period of time.

Results from the ex post facto analysis indicate that hedging with either heating oil futures or heating oil call options would have provided a tremendous overall savings to the DoD. Currently the DoD does not hedge its budget against fluctuation in the jet fuel spot market. The implication from this study is that the DoD should consider hedging its jet fuel exposure with either derivative, in particular call options as it is tailored for risk adverse customers.

Table of Contents

Page

List of Figures

List of Tables

Table Page

JET FUEL HEDGING STRATEGIES FOR THE DEPARTMENT OF DEFENSE THROUGH USE OF FINANCIAL DERIVATIVES

I. Introduction

Overview

Oil is one of the most important commodities on the global stage today and the United States consumed nearly 24.8 percent of the global supply in 2006 (EIA, 2008). It is the lifeblood of the global economy and the keystone asset required to sustain every industrialized nation. From being a factor in deciding what form of transportation we will use for travel to our National Defense Strategy; oil is everywhere in our lives. Consumption data from the Energy Information Agency (EIA) illustrates that as of 26 September 2008, the United States consumes roughly 18.5 million barrels per day of petroleum-based products. This consumption quantity is nearly eight percent lower from the 20.2 million barrels per day quantity taken from the same time in 2007. Price is a major factor in driving oil consumption and the average price for per barrel increased substantially from 2007 to 2008. In 2007, the average price per barrel of crude oil was trading for nearly 72 dollars and in 2008, the price increased to all most 150 dollars per barrel before the September crash. This statistic clearly demonstrates the impact that price has on the demand of petroleum-based products and the importance of oil in our everyday lives.

Over the past five years, the price per barrel of crude oil has grown dramatically. This price increase has created record-high prices for all by-products of crude oil, including Aviation Fuel, otherwise known as jet fuel. To put this into perspective, in

FY02, the Department of Defense (DoD) procured roughly 1.9 billion gallons of jet fuel on the domestic spot market at a total cost of nearly 1.3 billion dollars. In comparison, the DoD procured 1.5 billion gallons of jet fuel on the same spot market at a total cost that was slightly over 3 billion dollars in FY07 (DESC, 2008). Ultimately, this means that in FY07 the DoD purchased 80 percent of the jet fuel that it used in FY02 for a cost that was 230 percent higher.

Large price fluctuations in the crude oil market make the price of crude extremely volatile. Considering that jet fuel is a by-product of crude oil, there is a high correlation between the price of crude oil and jet fuel. The spot market price of jet fuel and the futures price of crude oil have a correlation factor of 0.9964. Figure 1 illustrates this correlation over the past twelve years, data obtained from the EIA.

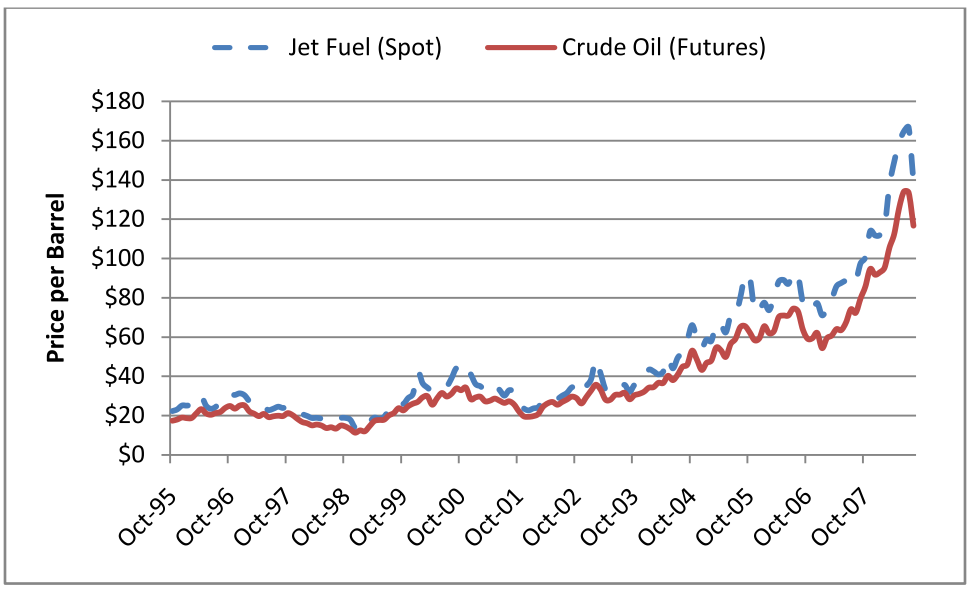

Figure 1. Commodity Price Correlation

Derived from crude oil, jet fuel goes through a refining process to achieve its final usable state. This refining cost causes the price of jet fuel to be slightly higher than the price of crude oil. Due to its derivative relationship with crude oil, many of the same factors that drive the crude oil market affect the price of jet fuel. Commercial airlines mitigate their exposure to the crude oil market by using a fuel hedge and many believe that it would be prudent for the DoD to implement a similar strategy. This paper will examine some of the strategies available to the DoD that could help reduce its exposure to the high volatility associated with the price of jet fuel. With a reduction in exposure to price volatility, the Defense Energy Support Center (DESC) should be able to provide the DoD with a stable jet fuel price, this is currently not the case.

Current Procedures

Currently the DESC procures all of the jet fuel used by the DoD throughout the fiscal year. DESC utilized the Defense Working Capital Fund (DWCF) to purchase more than 132 million barrels of fuel at a cost of 11.5 billion dollars in 2007 (DESC, 2008). The DWCF is a revolving fund that provides goods and services for the component military forces. DWCF Business Areas sell goods or services with the intent of recovering the total cost incurred. Unlike profit-oriented commercial businesses, DWCF Business Areas strive to break even over the long term, and set prices accordingly. Allowing the DWCF to operate at a loss one year and then a profit the next creates a zero sum gain. The Office of the Secretary of Defense (OSD), Comptroller establishes a stabilized standard price for aviation fuel, relying heavily upon Office of Management and Budget (OMB) forecasted crude oil prices. This standard price is to provide the military with budget stability using the DWCF reserves to absorb any volatility in the market. Over the past five years, the DWCF has had a difficult time in providing stable fuel prices to the DoD, causing a great deal budget instability for the armed services. Figure 2 shows the historical DESC standard price and the historical spot price of jet fuel from October 1995 to August 2008.

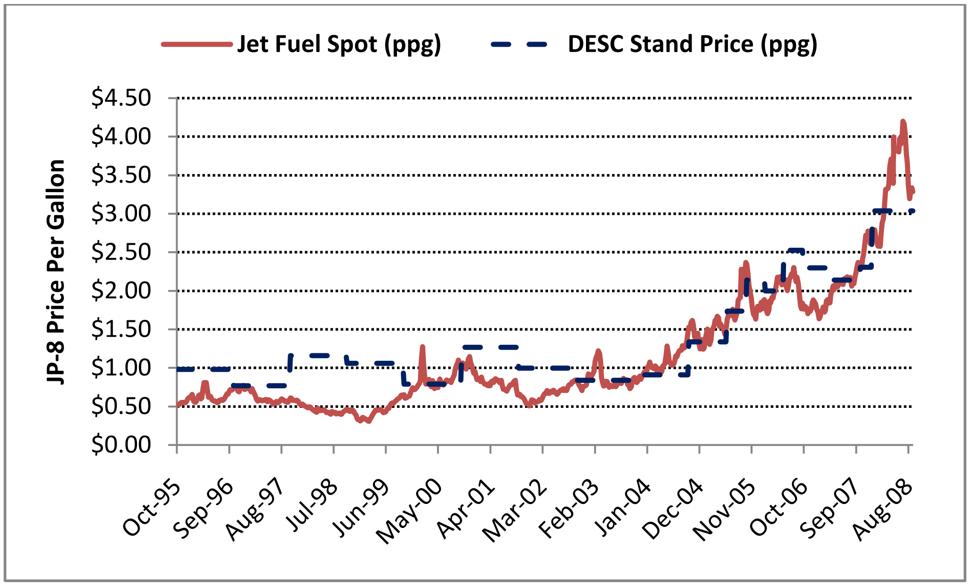

Figure 2. Historical Jet Fuel & DESC Standard Price Comparison

Prior to FY05, DESC provided a stable price to the DoD, only changing the standard price at the beginning of every fiscal year. However, starting in FY05 price volatility has forced DESC to change the standard price for jet fuel during the fiscal year. This adjustment in price makes it increasingly difficult for the services to budget appropriately for jet fuel, forcing the services to rely on Congressional supplemental funding in order to maintain mission readiness. In light of this escalating problem, OMB has urged the DoD to develop a strategy to include fuel hedging in its risk-control arsenal to deal with rampant prices of aviation fuel (Defense Business Board, 2004). Providing a stabilized standard fuel price is supposed to be one of strengths of the DWCF but this does not seem to be the case. To highlight this point, every year since 1992 Congress has adjusted either the budget-year fuel prices or appropriated additional funding to meet shortfalls (Chinn, Le Blanc, & Corbion, 2001). High price volatility has been the major driving force in underperforming forecasts in recent years. This volatility has caused the forecast to be grossly inaccurate and ultimately forced DESC to alter the standard price of fuel during the fiscal year. A 2002 Government Accountability Office (GAO) report examining fuel pricing concluded, “DoD has been trying to successfully implement the working capital fund concept for over 50 years. However, Congress has repeatedly noted weaknesses in DoD’s ability to use this mechanism to effectively control costs and operate in a business-like fashion” (GAO, 2002). Due to market volatility, the DWCF can either underestimate or overestimate the market strength each year. A scenario of insufficient funding is realized when the market is underestimated and there is high price volatility, leaving the DWCF unable to sustain itself. This forces DESC to change the standard price of fuel mid-year and share the increased burden with the DoD. In turn, the Services scramble for additional funding or take money from other programs to pay for the increase in fuel price (OSD, 2006). When the market is overestimated, then there is less money available for investment. Ultimately, current practices do not enable the DoD to plan and budget more confidently, in accordance with the DWCF’s mandate.

Commercial Sector

The DoD is not the only consumer of aviation fuel that has endured these cost increases, the commercial airline industry has suffered as well. For every one-dollar per barrel increase in aviation fuel, the airlines collectively pay 425 million dollars in additional operating costs. Realizing this, a majority of the airlines have developed risk management strategies to hedge a portion of their jet fuel needs for future use. Since September 11, 2001, Southwest Airlines is the most notable commercial carrier to implement a fuel hedge strategy and they are the only major US airline that consistently turns a profit (Alexander, 2004).

Southwest owes a great deal of its recent success to their fuel hedge strategy; it maintains a long-term fuel hedge program to keep its costs down. Within its fuel hedge portfolio, Southwest has purchased fuel options for years in advance to smooth out fluctuations in fuel costs. While hedging has provided a great deal of success in the past for Southwest, the recent decrease in the price per barrel of oil is forcing Southwest to realize a higher cost per gallon for fuel than its un-hedged competitors. Since Southwest uses a variety of derivatives to hedge, this increased cost will likely be marginal and equal only the premium amount associated with the contract.

In 2000, Southwest said it had "adjusted its hedging strategy" to "utilize financial derivative instruments... when it appears the Company can take advantage of market conditions" (SEC, 2001). Additionally, the company hoped to "take advantage of historically low jet fuel prices" (SEC, 2001). Southwest's foresight on the market positioned them to make profit windfalls in the following years. Southwest utilized a mixture of swaps and call options to secure fuel for future years while paying prices they believed were historically low. Prior to this change in strategy, Southwest hoped for reduced volatility in oil prices, just like a vast majority of other airlines. However, with the hedge in place, they now hoped for high prices and they got what they wanted. Higher prices allowed Southwest to capitalize off their investment and have a competitive advantage when setting fare prices. The use of fuel hedging helped Southwest maintain its profitability during the oil shocks related to the Iraq War and during the aftermath of Hurricane Katrina. According to the 2006 Southwest Annual report, on average Southwest paid less for a barrel of jet fuel than the Spot Market price from 2003 to 2006 because of its fuel hedge (SEC, 2006). Table 1 depicts the Southwest and Spot Market average annual price per gallon for jet fuel from 2003 to 2006. The delta represents the average amount of savings per gallon that Southwest obtained because of its hedged position.

Table 1. Southwest versus Spot Market Annual Price per Gallon

Year	Southwest Average Price	Spot Market Average Price	Delta
2003	$0.73	$0.87	$0.13
2004	$0.83	$1.20	$0.37
2005	$1.03	$1.72	$0.68
2006	$1.53	$1.95	$0.42

At the conclusion of 2007, Southwest Airlines had a 95 percent hedged position in place at a price of 50 dollars per barrel; this position will decrease substantially moving forward. According to the Wall Street Journal as of October 2007 Southwest Airlines had the hedge positions shown in Table 2. Table 2 shows the price per barrel that Southwest already maintains for its forecasted consumption amount for each year. Using 2008 as an example year, Southwest had 65 percent of its projected fuel consumption hedged at a cost of 49 dollars per barrel.

Table 2. Southwest Fuel Hedge Position

Year	Position	Price per Barrel
2008	65%	$49.00
2009	50%	$51.00
2010	25%	$63.00
2011	15%	$64.00
2012	15%	$63.00

In light of the current fluctuations in the oil market, these amounts could change significantly in the near future.

Problem Statement

Due to the erratic fluctuations in price for aviation fuel on the spot market over the past several years, the DoD has had to allocate additional financial resources to cover these unexpected costs creating unanticipated shortfalls during the current fiscal year

Research Question

The focus of this research is to determine the practicality and potential outcomes of utilizing two unique financial derivatives to reduce DoD financial losses caused from the increasing price of jet fuel. This research utilizes an ex post facto methodology, based off DoD cost and consumption data from Fiscal Year 96 to Fiscal Year 09. This analysis uses secondary cost data for two forms of financial derivatives covering the same period. We are going to compare how much the DoD did pay with the net amount it would have paid had a fuel hedging strategy been in place.

Significance

The significance of this research is that the DoD could potentially mitigate its exposure to the volatility of the crude oil market by implementing a hedging program. This reduction in exposure to price fluctuations could lead to a reduction of monetary losses due to the increased price of jet fuel on the spot market in the long run. There is a potential for millions of dollars in annual savings for the DoD. The DoD could use these savings to sustain mission operations reduce the need for supplemental funding.

Assumptions

One of the main assumptions of this research is that the world energy market contains enough liquidity to allow DoD entry into these markets without significantly influencing the price of the underlying derivative.

Chapter Summary

This study attempts to leverage off historical commodity cost data to create mock fuel hedging scenarios, determining if a financial savings could have be realized in the Department of Defense had a hedge strategy been implemented. To develop these scenarios, we use an ex-post facto methodology on the recorded commodity cost data over the past decade. The study uses recorded jet fuel spot prices as well as heating oil futures and call option prices. While the Department of Defense must procure fuel regardless the cost, this study seeks to reduce the total cost spent on fuel over the lifetime of the analysis and provide a greater base for budgetary stability for the armed services.

II. Literature Review

Chapter Overview

This chapter provides an overview of the research previously completed involving fuel hedging. We first describe terminology, concepts and instruments used in this study along with previous qualitative fuel hedging and quantitative currency hedging studies done. Covering risk management next and then some legal issues involving fuel hedging. From the information gathered in this chapter, we develop a historical and logical framework for the ex-post facto methodology scenario.

Terminology, Concepts and Instruments

The world of finance has its own unique language that is foreign to most individuals; this portion of the literature review will cover the terminology and concepts of the financial world that are required to understand this paper

Derivatives

The primary purpose of a derivative is to transfer risk from one party to another. A derivative is a financial instrument whose value is determined from either a cash market commodity, futures contract, or other financial instrument. Common types of derivatives include forwards, futures, options and swaps contracts (CME, 2006).

Futures Contract

Standardized forward contracts gave birth to today's futures contract. A futures contract is simply a standardized legally binding agreement between a buyer and seller in which the contract specifies the quantity, predetermined price, and future delivery date of the purchased commodity. The two main types of future contracts are physical delivery and cash settled. For a physical delivery contract, to settle open positions (positions not yet offset in the marketplace) in the market an offsetting futures trade or acceptance physical delivery is required. On the other hand, closing a cash-settled future contract position requires the seller to make an offsetting futures trade or simply leaving it alone and make one final mark-to-market settlement adjustment to close the position. According to the Chicago Board of Trade, only 3 percent of all futures contracts result in physical delivery or cash settlement, offsetting the other 97 percent on the market. This means that the majority of participants close out their positions prior to the contract's delivery date. If liquidation of these contracts does not occur by the last trading day of the contract month, comparing the position's price with a special final settlement price to either debit or credit the position is required before closing it out (CME, 2006).

Traded easily as standardized contracts, futures contracts may exchange ownership numerous times before the specified delivery date. It is in these exchanges of ownership that "speculating" takes place.

Forward Contract

A forward contract otherwise known as a cash forward sale is a private negotiation between a buyer and seller in the present that establishes the price and quantity of a commodity for delivery at a specified time in the future. Once delivered to the buyer, the commodity changes hands of ownership and payment is settled. Forward contracts differ from futures contracts by allowing payments to occur on a daily basis, enabling partial payments over the life of the contract. This type of instrument was particularly useful to merchants and farmers in the mid 1800s because it enabled them to lock in prices for a future delivery date, allowing them to hedge against price volatility in the market. To prevent either party involved in the trade from defaulting on the transaction, both parties are required to deposit a negotiated amount to a third party for holding until settlement. If one party breaks the agreement and defaults on the contract, the other member receives the deposited amount as compensation (CME, 2006).

Exercise

The action or ability of the buyer of an options contract to buy or sell the underlying futures contract. An option holder is the only individual who can exercise an option. Call holders can exercise the option to buy and put holders can exercise the option to sell the underlying future (NYMEX, 2004).

Strike Price

A strike price is the price at which the holder may exercise the option. Established when the option is first written, it along with time until expiration, volatility of the underlying security, and the current interest rate determines the premium amount to be paid for the option. For call options, the strike price is the purchase price of the commodity. For a put option, the strike price is the selling price of the commodity (NYMEX, 2004).

Premium

The price paid by the buyer to the seller in addition to the amount the futures price of the commodity. For example, if heating oil futures are trading for 80 dollars a barrel and call options are being sold for 83 dollars a barrel then the call option would have a three-dollar premium associated with it. The premium amount is the penalty the buyer will have to pay to the seller if they decide to let the contract expire instead of exercising the contract.

A variety of factors affect the monetary value of option premiums, including strike price as it relates to the underlying futures price, time until contract expiration and market volatility (NYMEX, 2004).

Underlying Futures Contract

The underlying is the price of the corresponding futures contract for that commodity. The September heating oil commodity contract is the underlying contract for September heating oil call and put options (NYMEX, 2004).

Volatility

Volatility is high in an environment where prices are rising or falling significantly. Alternatively, when a futures contract shows little price movement or increased stability, volatility is low. Commodities that experience high volatility garner higher premiums on their options on futures contracts. Increased price stability coupled with decreased volatility environments generally cause options premiums to decline. Volatility coupled with time until expiration, strike price, and the current interest rate determines the premium amount for the option (NYMEX, 2004).

In-the-money

Having positive intrinsic economic value, a call option is in the money when the commodity futures price exceeds the option’s strike price. For example, a December heating oil call option is in the money if the December strike price were beneath the futures trading price. Enabling the option holder the ability to exercise the contract and obtain the commodity at a value less than the market rate (NYMEX, 2004).

At-the-money

Having neither positive nor negative intrinsic economic value, an option is at-the-money when the futures price and the strike price are equal to one another (NYMEX, 2004).

Out-of-the-money

Having a negative intrinsic economic value, a call option is out-of-the-money when the commodity futures price is less than the option’s strike price while a put is out-of-the-money when the commodities futures price is above the option's strike price (NYMEX, 2004).

Call Option Contract

Call option futures contracts provide the buyer the right to purchase the underlying futures contract at an agreed upon strike price; but it does not obligate them to do so. This instrument does obligate the seller to sell the underlying if the buyer chooses to exercise the call option. The buyer pays a premium for the option, compensating the investor for the risk associated with fluctuations in the price of the underlying stock or commodity. From an investors perspective, the buyer of a call wants the value of the underlying to increase after they have purchased the option because then they will make a profit off their investment (CME, 2006).

Call options on futures contracts differ from typical futures contracts in that they provide the buyer with a way out of the contract that only costs the buyer the amount of the premium. The following example highlights the differences between the two types of contacts a buyer face when purchasing heating oil contracts. Assume that a barrel of heating oil is trading for 80 dollars per barrel on the futures market. Buyer 1 purchases a futures contract for 80 dollars per barrel; buyer 2 purchases a call option on the futures contract for 80 dollars per barrel plus a 3-dollar premium, totaling 83 dollars per barrel. Both contracts are for the same quantity of heating oil and expire at the same time. After some time goes by both contracts reach their expiration date and heating oil is now trading for 70 dollars per barrel. In this scenario, buyer 1 would be forced to pay the agreed upon 80 dollars per barrel even though the current price of heating oil is now only 70 dollars per barrel. Buyer 2, on the other hand, would simply let their contract expire and forfeit the premium amount of 3 dollars per barrel. Then they would purchase heating oil at the prevailing market-rate of 70 dollars per barrel, making 73 dollars per barrel their total cost. In this scenario both buyers obtained the same amount of heating oil but buyer one ended up paying 7 dollars more per barrel than buyer two for the same amount of the heating oil. Buyer 1 paid 7 dollars more than buyer 2 because buyer one paid 80 dollars per barrel instead of 73 dollars per barrel when they purchased their contract.

Now let us use this same scenario but this time, at the time of expiration, heating oil is trading for 90 dollars per barrel. Buyer 1 is happy that they purchased their contract when heating oil was trading for 80 dollars per barrel and gladly pays the agreed upon 80 dollars per barrel. Buyer 2 feels good about this situation as well, because they can exercise their call option to purchase heating oil at 83 dollars per barrel; in this scenario, both buyers come out ahead. Buyer 1 is the bigger winner and saves 10 dollars per barrel. Since buyer 2 paid 83 dollars per barrel for a commodity that is trading for 90 dollars per barrel, they save 7 dollars per barrel.

So far we have seen how beneficial call options can be for a consumer, but there are scenarios where that is not the case. Assume that heating oil is trading for 82 dollars per barrel at contract expiration. Buyer 1 simply pays their agreed 80 dollars per barrel price and saves 2 dollars per barrel. Buyer 2 will choose to execute their call option and pay 83 dollars per barrel, putting them in a situation where they are paying 1 dollar more than fair market value for heating oil. Buyer 2 chooses to execute their option instead of letting it expire because of the 3-dollar premium associated with the call option. If buyer 2 had let the contract expire it would have forced them to purchase heating oil at 82 dollars per barrel off the spot market. This 82-dollar per barrel price plus the 3-dollar per barrel premium cost would make their total cost equal 85 dollars per barrel. In either situation buyer two is paying more per barrel than the fair market value.

Hedge

The undertaking of either a either a long or short position by purchasing futures contracts or options contracts in order to mitigate exposure to price volatility. For example, the purchase of heating oil futures contracts in July that is set to expire in December (NYMEX, 2004).

If you are "going long" then you are a holder who has established a market position by purchasing futures or options contracts with the anticipation that prices of the underlying commodities will increase. From a profit perspective, a holder who maintains a long position will profit if the price of the underlying security increases. A holder of a short position profits off a decrease in price for the underlying security. Consumers that make bulk purchases such as electric companies, manufacturing companies, gasoline station owners and other high volume buyers feel the need to protect themselves against high acquisition cost. By taking a long position, companies can manage their exposure to increasing prices by implementing this type of strategy (CME, 2006).

Similar Studies

The topic of fuel hedging has garnered many headlines over the past five years, most of which can be contributed to the successful hedging strategy implemented by Southwest airlines. Recognizing the success of Southwest and potential benefit that could be gained by fuel hedging, the Office of Management and Budget (OMB) urged the Department of Defense (DoD) in 2004 to develop a strategy to include fuel hedging in its risk-control arsenal to deal with the rampant prices of aviation fuel (Defense Business Board, 2004). Despite this recommendation from OMB, there has been little analytical research done in this arena by the DoD. The November 2006 edition of the *Air Force Journal of Logistics*, the article "Fuel Hedging, A Lesson from the Airlines" by Lawrence Spinetta highlighted the impact that volatility in the jet fuel price can have on the Air Force budget. Spinetta advocated for the implementation of a fuel-hedging program within the DoD (Spinetta, 2004). In March 2008 a Naval Post graduate Thesis titled "Should the Department of Defense Hedge Oil Prices In Order To Save Money" written by James Knapp suggested that the DoD should not enter into a hedging position due to the negative public perception, inherent risk in hedging, and the lack of political support (Knapp, 2008). Both of these studies make compelling arguments for their respective positions on the topic, but neither provides any analytical support to bolster their argument. Although there has not been any quantitative research done on fuel hedging from a DoD position, there has been published quantitative research done on currency hedging.

Groshek and Felli (2000) ran a Monte Carlo simulation to determine the effects of hedging the Air Force Overseas Operations and Maintenance budget in the Japanese Yen, British Pound or German Mark. Of all of the hedging methods available, the authors chose to use forward and option contracts as their instruments of choice. The authors collected data from 1985 to 1998, providing them with a total 14 years of worth of budgetary data. Their findings showed that using these hedging instruments would achieve six to seven percent savings. They concluded that it would be in the best interest of the DoD to utilize a hedging strategy with an emphasis placed on using options (Groshek & Felli, 2000).

Edwards (2008) found that by using futures contracts to hedge against the EURO from 2001 to 2007, on average the DOD could have realized 171 million dollars in savings. This certainly emphasizes the importance of exploring the potential of using hedges as a technique to increase budget stability (Edwards, 2008).

Risk Management

Confronted with the fact that risk is unavoidable when acquiring major weapon systems, the DoD has outlined a path for its program managers to follow that will assist them in managing risk associated with procuring weapon systems. The Risk Management Guide for DoD Acquisitions identifies risk as, “A measure of future uncertainties in achieving program performance goals and objectives within defined cost, schedule and performance constraints" (DAU, 2006). The basic definition of risk still holds true when applied to other large acquisitions, such as the purchase of jet fuel.

Outside of investor profit maximization, one of the primary purposes of using financial derivatives to implement a hedging strategy is to reduce market risk and mitigate price volatility. Dr. Rene Stulz (1996) explores the apparent disconnect between the theory and actual practice of corporate risk management. From a theory perspective, companies facing a large amount of exposures to commodity prices can increase their market values by using financial derivatives to create a hedge and reduce exposure, with the primary emphasis of the hedge being a reduction in price variability. However, the design of most hedging positions taken today is for the "elimination of costly lower-tail outcomes -- that is to reduce the expected costs of financial trouble while preserving a company's ability to exploit any comparative advantage in risk-bearing it might have" (Stulz, 1996). As an example of what can happen when a company implements a hedging strategy that doesn't aim at minimizing the variance, Stulz cites the example of Metallgesellschaft Refining and Marketing (MGRM) in 1993 (Stulz, 1996). MGRM implemented a strategy that hedged long-term oil commitments on a one-to-one basis with short-term futures in 1993, believing they could profit from price movements due to their specialized information about supply and demand. Unfortunately for MGRM, spot prices fell dramatically during 1993. The decline in spot prices led to a financial loss of 1.25 billion dollars for MGRM, with over 800 million dollars in losses in the fourth quarter alone forced MGRM into bankruptcy. MGRMs downfall illustrates the negative consequences of what can happen when a company enters into a hedging strategy based off practice instead of theory. Had MGRM taken a theory approach to their hedging strategy then they would have only had a hedging position that was large enough to mitigate their exposure to downward price movement in the oil market. Instead, MGRM practiced aggressive hedging tactics hoping to capitalize off their specialized supply and demand information knowledge.

For another example of what can happen to a company when it does not implement a good hedging strategy, you only need to look at the airline industry. United Airlines had roughly 30 percent of its fuel consumption hedged for the first quarter of 2008 and experienced a 537 million dollar loss compared to Southwest, which had a 70 percent hedge that enabled it to garner a modest 34 million dollar profit (Gaffen, 2008). United Airlines experienced costly financial losses by poorly hedging against what Dr. Stultz would call “costly lower tail outcomes”. The understanding of theory behind risk management and the implementation of its policies is critical to any corporation, clearly portrayed throughout the literature on the topic. Hedging exposure to the price volatility of jet fuel is one of the ways a company can attempt to minimize its risks.

The DoD will need to a pursue a hedging strategy that is designed to mitigate exposure to price volatility. This strategy will not introduce speculation or seek to obtain additional resources to offset other financial shortfalls. By practicing a smart hedging strategy, the DoD will be able to moderate their exposure to oil price increases and avoid it creating instability in the DoD budget. Increased budgetary stability during a time when the DoD could be facing declining budgets is a step in the right direction.

Legal Issues

The DoD faces three challenges that it must overcome before it can implement a fuel hedging strategy. First, the DoD has no specific authority to engage in transactions involving derivative products because the DoD's general procurement is limited to products and services. Second, the DoD lacks authority to derive cash benefit from liquidated positions in financial markets. Currently, proceeds from liquidated positions would go directly to the Treasury rather than into the DWCF. Third, the General Accounting Office (GAO) has not addressed whether hedging budget risk is a "*necessary expense*" for federal agencies. The necessary expense rule in the 2004 GAO Redbook states:

> It is a well-settled rule of statutory construction that where an appropriation is made for a particular object, by implication it confers authority to incur expenses which are necessary or proper or incident to the proper execution of the object, unless there is another appropriation which makes more specific provision for such expenditures, or unless they are prohibited by law, or unless it is manifestly evident from various precedent appropriation acts that Congress has specifically legislated for certain expenses of the Government creating the implication that such expenditures should not be incurred except by its express authority.

If the Comptroller General deemed that fuel hedging was a necessary expense then it would be legal. Currently there is not an established formula for determining the application of the necessary expense rule (GAO, 2004).

Market Implications

Due to the large quantity of jet fuel that the DoD procures on the spot market, it is feasible that if the DoD did enter into a jet fuel hedging position by using heating oil futures, it could increase the value of the heating oil futures contracts on the market.

Currently, crude oil accounts for nearly 40 percent of the world's energy and it is the most actively traded physical commodity on the market today (NYMEX, 2007). Heating oil accounts for roughly 25 percent of the yield of a barrel of crude, making it third on the list behind gasoline (NYMEX, 2007). Multiple commercial businesses such as airlines, trucking companies and other major consumers of fuel use heating oil to hedge fuel cost by actively trading contracts on the market. Considering the demand for these contracts both domestically and abroad, and the size of the market, it is my opinion that if the DoD had purchased 120 contracts over ten years, it would probably not have a large impact and sway the market in either direction.

Chapter Summary

In this chapter, we described several studies that look at fuel hedging and currency hedging in the DoD. From these studies, we derive that hedging can be a useful instrument in reducing cost for a multiyear program. In addition, we covered a plethora of terminology, concepts and instruments that used in the financial community. Finally, we looked at the legal barriers that currently exist that prevent the DoD from legally implementing a fuel-hedging program and the market implications associated with the DoD entering into a hedging position.

III. Methodology

Chapter Overview

This chapter describes the process that used to conduct this research. We begin by outlining the data employed by this quantitative study, followed by an explanation of how the hedge scenario works for both futures and call option contract. The last topic addressed in this chapter is an explanation of the ex-post facto methodology used to perform this study.

Data Measures

DESC provided monthly DoD fuel consumption data for this analysis. According to DESC, the DoD procures roughly 50 percent of its jet fuel on the domestic spot market while procuring the other 50 percent on foreign markets. Some of the fuel obtained off the foreign market comes at a discount price and for that reason it was not included in this analysis. The data collected for this analysis provides the total gallons procured on the domestic market and the weighted average price per gallon for each specific month from October 1995 to September 2007, enabling the study to start in FY96 and conclude in FY07. The provided data represents the historic procurement cost per gallon for fuel consumed by the DoD.

The commercial sector uses both heating oil and crude oil financial derivatives to create jet fuel hedging positions, but heating oil derivates are the preferred instrument for creating jet fuel hedges (NYMEX, 2007). In testing the correlation between heating oil and jet fuel, I used over three thousand end of day historical prices for both of the petroleum-based products and obtained a correlation factor of 0.9983. This factor was slightly higher than the 0.9964 factor that jet fuel and crude oil shared so; this analysis only uses heating oil derivatives as the underlying.

This study uses heating oil futures data obtained from the Center for Futures Trade Commission (CFTC) to match the DESC fuel procurement time frame. The data provided from the CFTC is the settle price for each contract (November through October) on the first business day of every fiscal year from FY96 through FY07. This analysis used the end-of-day settle prices to prevent speculation from tampering with the results. End-of-day settle prices are closing prices and reflect the amount a stock or commodity traded at the close of business for that day. All futures contracts expire on the last business day of the preceding month. For example, the September 2008 futures contract expired on 29 August 2008.

The New York Mercantile Exchange (NYMEX) provided financial data for trading the underlying heating oil call option derivatives for the same timeframe. This analysis will try to maintain an “at the money” position when determining the strike and settle prices for call options. Since these are historical data, there are not “at the money” prices for every month in every year. This analysis uses the closest strike price and settle price when this occurs. If no strike price exists for a month, the corresponding DESC weighted spot price is used and a hedge will not exist for that month. There were 9 strike and settlement prices missing out of 144 needed to hedge the DoD for the timeframe of this analysis. All call option contracts expire three business days prior to the futures expiration date. For example, the September 2008 call options contract expired on 26 August 2008, whereas the September 2008 futures contract expires on 29 August 2008.

Futures and options contracts were the financial derivatives utilized for this analysis. Although other financial tools such as SWAPs and forwards are available on the market to create a hedging position, they are not within the scope of this analysis. This analysis used call options contracts instead of put option contracts. The DoD is a not-for-profit entity and using call options to hedge against an increase in the spot price of jet fuel is less speculative in nature. Therefore, any "in the money" gains realized from executing a contract would not be perceived as profit but more so as a reduction of cost. The DoD would not accept physical delivery at settlement instead the DoD would s use the profit realized from executing the contract to offset the current spot price of jet fuel. By engaging in this practice, the DoD would only use profits to offset fuel costs.

Transaction costs for purchasing futures and call options on the exchange, as well as purchasing jet fuel on the spot market have not been included in this analysis. For purchasing heating oil future or option contracts a buyer realizes NYMEX clearing cost, commission fees and brokerage costs. The culmination of these expenses total between 4 to 12 dollars per contract traded. These costs are dependent upon clearing member status, the total quantity traded, and the brokerage firm that is executing the trade. In a situation when a consumer executes two contracts (each contract consisting of 42,000 gallons) the transaction cost would range from 8 to 24 dollars. The buyer realizes a profit or loss based on the spread between the Bid and Ask price, not the transaction expense. Currently, DESC makes multiple purchases of jet fuel on the spot market throughout the year. On many occasions, DESC makes several purchases of jet fuel on a daily basis. These transaction cost do not deter DESC from making them in their current structure and would not prevent them from making purchases on the commodities trading market.

Transactions costs on either the spot or the futures market are simply the cost of doing business and are absent from this analysis.

This analysis used the first day of the fiscal year as the execution date to establish the hedging positions, typically the first trading day or business day of October. As stated before, the closing or settle price on the underlying contract was chosen rather than the open, high, or low price of the day; removing the effect of speculation. With the fiscal year starting in October, contracts in the corresponding fiscal year were chosen with expiration dates in November, December, January, February, March, April, May, June, July, August, September and October. To cover all of the months by this hedging position, the purchase of October contracts for the next fiscal year at the same time as the other monthly contracts was completed. An example of this would be purchasing an October 2007 contract in October 2006. For the first fiscal year, this analysis uses the DESC purchase price for jet fuel in the month of October, as it will take one month to create the hedging position.

This analysis will provide two hedging models for futures and two models for call options, both derivatives will share the same models. The first model will show the "then year" cost savings or loss resulting from the hedge. The second model will show the "constant year" cost savings or loss resulting from the hedge. We will use the Gross Domestic Product deflator to convert the "then year" dollars to "constant year" 2000 dollars. We converted the hedged results into "constant year" dollars to determine the summation of the hedged savings or loss over the duration of the analysis. Constant year 2000 was chosen because the range of the fiscal years used in this analysis cover FY96 through FY07, thereby using cost data from 1995 to 2007.

This hedging strategy analysis is passive, removing most of the analytical responsibility from the individuals who manage the Defense Working Capital Fund (DWCF). The manager of the DWCF would simply assume a zero percent, 25 percent, 50 percent, 75 percent, or 100 percent hedging position (either with futures or options) to cover the jet fuel procured on the domestic spot market. By observing five different hedging positions one will be able to determine the best and worst possible outcomes.

We have made no effort to determine whether the derivatives used in this analysis are over or under valued; the assumption is that the “invisible hand” is at work and that prices will change rapidly to reach equilibrium. Utilizing this passive/automated strategy removes all responsibility for determining whether to initiate a contract from the analyst; eliminating the possibility of the DoD introducing speculation into the market because the analyst has such a minor role. The only thing the analyst will have to do is to decide whether to execute the option or not.

Futures Hedge Mechanics

On the surface, a fuel hedge seems simple; a buyer purchases heating oil futures contracts now with the intent of selling the contracts later to protect against future price increases in jet fuel. The mechanics behind the hedge are not so simple, differing slightly for futures and call option strategies.

When dealing with future contracts, the hedge decision-making process is straightforward because the buyer has to abide by the specifications of the contract. Table 3 represents the mechanics of a futures hedge for this analysis. All figures and amounts shown in Table 4 are to be treated as fictitious as they are not the amounts used in the actual analysis. As mentioned before, for this analysis the purchase of the heating oil futures contracts takes place starts on the first business day of the Fiscal Year.

Table 3. Hedging with Futures Scenario

Month	**Variable**	**Jan-96**	**Feb-96**	**Mar-96**	**Apr-96**
JP8 Total Gallons Purchased	**A**	84,000	126,000	168,000	126,000
DESC Un-hedged ppg	**B**	0.65	0.55	0.55	0.65
HO Futures Purchase ppg	**C**	0.50	0.60	0.45	0.45
HO Futures Closing ppg	**D**	0.59	0.54	0.62	0.63
Profit per gallon after sale	D - C = **E**	0.09	-0.06	0.17	0.18
Jet Fuel Spot ppg at EOM	**F**	0.60	0.56	0.64	0.77
Hedged Price of Jet Fuel	F - E = **G**	0.51	0.62	0.47	0.59

Using the information from Table 3, the following scenario will explain how the futures hedge works. On the first business day of FY96, a buyer purchases a certain quantity of heating oil futures contracts for January 1996 through April 1996, at the fair market price (Variable C). The buyer holds the contract until it reaches expiration and sells the contract at the current heating oil futures market price (Variable D). Upon selling, the contract for a specific month either a gain or loss per gallon is realized (Variable E). If the previous transaction realizes a profit, this amount per gallon will decrease the current price per gallon of jet fuel (Variable F) by the same amount leaving the buyer with their hedge price of jet fuel (Variable G). Since the buyer purchased a certain quantity of heating oil futures, contracts the buyer can now purchase the same quantity of jet fuel gallons at the hedged price of jet fuel.

Using the prices from Table 3, let us look at how the final “Hedged Price of Jet Fuel” came to be for January 1996. On 1 October 1995, DESC purchased 84 thousand gallons worth of January 1996 heating oil future contracts at a price of 0.50 dollars per gallon. The contract expires on the last business day in January 1996; at that time, DESC sells the January 1996 contract for the market price. The end of the month market price for heating oil is 0.59 dollars per gallon, enabling DESC to make 0.09 dollars per gallon profit. Since DESC is not a profit making organization, DESC takes the 0.09 dollars per gallon they received off the transaction and uses it to offset the current spot price for jet fuel. The spot price for jet fuel is 0.60 dollars per gallon on the last business day of January 1996. DESC is able to offset this 0.60 dollar per gallon amount with 0.09 dollar per gallon profit it made off the futures transaction, thereby giving DESC a 0.51 dollar per gallon cost for jet fuel. At this 0.51 dollar per gallon price DESC would have a total cost of 42,800 dollars for jet fuel if DESC hedged all of their gas consumption for the month of January 1996. Note that for this scenario the un-hedge weighted average jet fuel price per gallon for DESC was 0.65 dollars per gallon, meaning that DESC spent 54,600 dollars for 84 thousand gallons of jet fuel. The un-hedged scenario uses the DESC weighted average jet fuel price per gallon because it most closely represents the actual cost that DESC had for that actual month.

Most of the scenarios in Table 3 yield a lower hedged cost for jet fuel over the un-hedged scenario. If a loss occurred instead of a profit when trading the futures contracts for the current market value, this would force DESC to purchase jet fuel at the end of month spot market price. For the month of February 1996, the purchase price for the futures contracts is 0.60 dollars per gallon and the closing price is 0.54 dollars per gallon, creating a loss of 0.06 dollars per gallon. Adding the 0.06-dollar loss to the 0.56 dollar per gallon spot market price for jet fuel in February makes the total hedged cost for jet fuel equal 0.62 dollars per gallon. The 0.62 dollar per gallon cost is 0.07 dollars more than the 0.55 dollar per gallon historical weighted DESC price. The total cost for the hedged position would be 8,820 dollars more than the historical un-hedged position.

Call Option Hedge Mechanics

Call options hedging strategies follow a similar methodology to hedging with futures but differ slightly due to the premium associated with the call option on futures contract. Table 4 further depicts the call option strategy used for this analysis.

Table 4. Hedging with Call Option Scenario

Month	**Variable**	**Jan-96**	**Feb-96**	**Mar-96**	**Apr-96**
JP8 Total Gallons Purchased	**A**	84,000	126,000	168,000	126,000
DESC Un-hedged cost	**B**	0.65	0.55	0.58	0.65
HO Futures Strike ppg	**C**	0.50	0.50	0.49	0.48
HO Futures Settle	**D**	0.59	0.49	0.50	0.63
HO Call Option Settle	**E**	0.01	0.01	0.02	0.02
HO Strike with Premium	C + E = **F**	0.51	0.51	0.51	0.50
Profit off of Call	D – F = **G**	0.08	-0.01	-0.01	0.13
Jet Fuel Spot ppg	**H**	0.60	0.56	0.64	0.77
Gains or Loss From Hedge	H – G = **I**	0.52	0.57	0.65	0.64

Many of the same steps from the futures hedge process hold for the call options strategy, but the premium does change things slightly. To state the obvious, since the buyer has the option, they will only do so when it is to their advantage. In most instances, when the buyer calls an option the buyer receives a profit (Variable G). It is important to note that a buyer will still call an option if the loss incurred from calling the option is less than the cost of the premium. The delta between the heating oil closing price (Variable D) and the total price of the call option (Variable F) determines the profit

(Variable G). Using the profit per gallon (Variable G) to reduce the jet fuel spot price (Variable H) creates the final price per gallon available because of the hedge (Variable I).

The following example of hedging with call options uses the price amounts shown in Table 4. On the first day of fiscal year 1996 for the January 1996 heating oil call option, the strike price is 0.50 dollars per gallon and the premium is 0.01 dollars per gallon, providing a total cost of 0.51 dollars per gallon. At the time of expiration, the January 1996 heating oil futures are trading for 0.59 dollars per gallon. DESC would call the option and pay 0.51 dollars per gallon for 84,000 gallons. DESC would then sell those same 84,000 gallons at the market price of 0.59 dollars per gallon, thereby making a 0.08 dollar per gallon profit off the sale. DESC would then use that 0.08-dollar profit per gallon to offset the current market 0.60 dollar per gallon spot price for jet fuel, thereby giving DESC a final cost of 0.52 dollars per gallon for jet fuel. In this scenario, it was in DESCs best interest to call the option but that is not always the case.

At the time of expiration, if the price of heating oil futures is less that the total cost of the call option, then it is probably in DESCs best interest to let the call expire. By letting the call expire, DESC forfeits the premium or settle amount associated with that contract. In doing so, DESC adds the forfeited settlement amount to the jet fuel spot price, which creates a higher price per gallon that DESC pays due to the hedge. Using the data from Table 4, for the month of February 1996, DESC would forfeit the premium and realize the loss. The February 1996 strike price is 50 cents per gallon and the premium is 1 cent per gallon, creating a total cost of 51 cents per gallon. At the time of expiration, the closing price for heating oil futures is 49 cents per gallon. This is a 2-cent difference and in this instance, it would be best for DESC to let the option expire and accept the 1-cent cost of the premium as a loss. DESC would have to add that 1-cent loss to the spot market price of 0.56 dollars per gallon and realize a 0.57 dollar per gallon final cost for jet fuel for February 1996. Since heating oil futures were less than the total cost of the call option for February 1996, it was in DESCs best interest to let the call expire. Note, though, that this is not always the case.

There are instances when DESC will call the option even though the futures price is less than the total cost of the call option. Using the price from Table 4 for the month of March 1996, the strike price is 0.49 dollars per gallon and the premium is 0.02 dollars per gallon for call options. This total price of 0.51 dollars per gallon is more than the 0.50 dollar per gallon price of heating oil futures at that time. In this case, DESC will call the option despite the futures price being less than the total cost of the call. They do this because the delta between the total cost of the option and the futures price is 0.01 dollars per gallon, which is less than the 0.02 dollar per gallon premium. By calling the option, DESC incurs less of a loss on the resale of the futures than if they forfeited the premium.

Using call options can create profitable situations for the buyer as well as minimize financial losses. As shown in the previous examples, call options provide the buyer the power of choice and can be extremely beneficial for the holder. This power of choice is a luxury and comes with an additional price, but it can be worth it in the end.

Data Analysis

This is an *ex post facto* analysis; the data is analyzed to determine what the results would have been if the DOD had implemented a hedge position either with futures contracts or call options contracts on futures for heating oil at the beginning of each fiscal year. For this analysis, the purchase of all hedging contracts occurred at the beginning of each fiscal year. In terms of call option contracts, this analysis will execute “at the money” or “in the money” contracts upon the expiration date of the contract. This analysis will execute “out of the money” contracts when the loss associated with the execution is less than the premium cost of the option contract.

This analysis will compare the net difference in these hedged trades on a monthly basis to the non-hedged results over this twelve-year period to determine potential savings. The results from this methodology should reveal which hedging position (if any) would have provided the greatest amount of savings to DoD for that timeframe. The DoD procures jet fuel constantly during the fiscal year. Table 5 illustrates the percentage of DoD jet fuel purchased per month for each fiscal year.

Table 5. Monthly DoD Jet Fuel Procurement Percentages

Fiscal	1st Quarter			2nd Quarter			3rd Quarter			4th Quarter		
Year	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**
96	7.1	8.5	7.3	8.4	8.1	10.2	9.3	8.1	8.8	8.3	7.3	8.5
97	7.6	7.9	6.9	7.1	9.0	9.1	8.6	8.2	9.0	8.5	8.6	9.7
98	7.5	9.3	6.7	6.9	8.0	7.5	8.2	9.5	9.4	8.8	9.9	8.2
99	7.8	7.8	8.9	7.2	7.1	8.7	9.4	8.1	9.0	8.1	9.2	8.6
00	6.8	7.6	8.0	8.7	7.9	7.5	8.9	7.9	9.9	10.4	7.7	8.6
01	7.9	7.2	6.9	9.2	7.2	7.8	9.4	8.9	8.3	8.1	9.6	9.5
02	8.7	8.2	7.7	8.2	8.4	10.2	8.2	8.2	8.8	7.2	7.5	8.9
03	9.1	6.3	9.4	8.1	9.1	7.0	7.8	9.6	7.1	8.5	9.1	8.8
04	8.9	6.6	7.7	6.7	7.3	9.3	9.7	7.9	9.7	9.3	9.2	7.5
05	9.5	8.5	8.6	6.8	6.6	9.6	8.1	9.9	9.3	8.2	8.2	6.7
06	9.2	7.7	9.2	6.5	7.7	9.2	8.0	8.4	8.8	8.9	8.4	7.9
07	6.7	7.1	7.0	9.0	7.9	9.0	7.6	9.1	9.0	10.4	8.8	8.3
Mean	8.1	7.7	7.9	7.7	7.9	8.8	8.6	8.7	8.9	8.7	8.6	8.4
Std Dev	1.0	0.8	1.0	1.0	0.7	1.1	0.7	0.7	0.7	0.9	0.8	0.8

As shown in Table 5, most of the time, the DoD roughly procures between seven and nine percent of its annual consumption amount of jet fuel each month. From a quarterly perspective, the DoD procures roughly twenty-five percent of its annual amount of jet fuel each quarter, thus illustrating a relatively constant purchase stream. This constant purchase stream means that the DoD can target each month equally when planning a hedge instead of targeting a few months for bulk purchases when creating a hedge.

Using the research to show causality and to create a direct hypothesis is two of the most prominent difficulties of using an ex post facto experiment (Babbie, 1986). Studies overcome these hurdles by limiting the subjects researched and the amount of variables tested. Additionally, in ex post facto experiments based off historical numerical data, the experimenter can control the amount of variables used in the study to avoid these problems.

Chapter Summary

This chapter sets forth our quantitative ex-post facto methodology. Further, we discussed how this analysis would deal with missing values. In addition, we explained the mechanics of a fuel hedge, how it functions when using future and call option derivatives. Finally, we explained the different hedging positions that were going to be testing in order to find which (if any) would yield the greatest savings for the DoD

IV. Results and Discussion

Chapter Overview

The chapter reviews the results of the hedge models used in this analysis. We will examine the results of the futures hedging model in "then year" and "constant year" terms first. Secondly, we will assess the call option hedging model results in "then year" and "constant year" denominations.

Hedging with Futures Results and Analysis

After running the futures models, it became apparent that hedging jet fuel with heating oil futures would have saved the DoD money; Table 6 shows the then year results of this analysis. Each hedge position in Table 6 shows the annual savings or loss realized after comparing the hedged amount to the historical price paid by DESC for that fiscal year. Positive values in Table 6 indicate that the hedge outperformed the historic DESC purchase price, while negative values indicate that purchasing off of the spot market was a better deal for the DoD in that fiscal year. The average savings row at the bottom of Table 6 is simply the average for the entire column. The Average Savings row shows that even with losses over the twelve-year period the hedge position outperformed purchasing jet fuel off the spot market. Over the twelve-year period used for this analysis, hedge positions outperformed buying off the spot market eight times, creating millions of dollars worth of savings.

Table 6. Annual Then Year Results of Hedging with Futures

Fiscal Year	Hedge Position 25%	50%	75%	100%
96	$41,598,030	$83,196,061	$124,794,091	$166,392,122
97	$12,024,421	$24,048,843	$36,073,264	$48,097,686
98	-$43,277,592	-$86,555,184	-$129,832,776	-$173,110,368
99	-$3,732,707	-$7,465,415	-$11,198,122	-$14,930,830
00	$87,226,900	$174,453,800	$261,680,700	$348,907,600
01	$2,504,828	$5,009,656	$7,514,484	$10,019,312
02	-$7,279,629	-$14,559,259	-$21,838,888	-$29,118,518
03	$35,604,752	$71,209,503	$106,814,255	$142,419,007
04	$103,349,627	$206,699,253	$310,048,880	$413,398,507
05	$112,022,366	$224,044,732	$336,067,098	$448,089,464
06	-$31,885,395	-$63,770,790	-$95,656,185	-$127,541,580
07	$1,445,364	$2,890,729	$4,336,093	$5,781,458
Avg. Savings	**$25,800,080**	**$51,600,161**	**$77,400,241**	**$103,200,322**

According to the model, the greater the hedge position the higher the savings for the DoD. In then-year terms, on average the DoD could have realized a 103.2 million dollar savings per year had it hedged all of its jet fuel purchases over the twelve-year period. It is important to note that in this model the DoD would have realized losses in FY98, FY99, FY02 and FY06 had it taken any hedging position. The impacts of these losses are better understood in the Constant Year model, Table 7. .

Table 7 shows the results of Table 6 in constant year 2000 dollars. As mentioned in Chapter 3, we used the gross domestic product deflator to convert the values from Table 6 into constant year 2000 dollars. Since all of the values are now the same constant year 2000 denomination, Table 7 adds a total row to the analysis. With the total row added, we can now show how much money the DoD could have saved over the twelve-year period had it hedged with futures.

Table 7. Annual Constant Year 2000 Results of Hedging with Futures

Fiscal Year	Hedge Position 25%	50%	75%	100%
96	$45,163,215	$90,326,429	$135,489,644	$180,652,859
97	$12,812,110	$25,624,220	$38,436,330	$51,248,440
98	-$45,357,696	-$90,715,392	-$136,073,088	-$181,430,784
99	-$3,869,213	-$7,738,427	-$11,607,640	-$15,476,853
00	$89,127,089	$178,254,179	$267,381,268	$356,508,358
01	$2,504,828	$5,009,656	$7,514,484	$10,019,312
02	-$7,109,083	-$14,218,165	-$21,327,248	-$28,436,330
03	$34,173,891	$68,347,782	$102,521,673	$136,695,564
04	$97,129,456	$194,258,913	$291,388,369	$388,517,825
05	$102,339,045	$204,678,091	$307,017,136	$409,356,182
06	-$28,208,676	-$56,417,352	-$84,626,028	-$112,834,704
07	$1,238,785	$2,477,569	$3,716,354	$4,955,139
Total	**$299,943,752**	**$599,887,503**	**$899,831,255**	**$1,199,775,007**
Avg. Savings	**$24,995,313**	**$49,990,625**	**$74,985,938**	**$99,981,251**

On average, over the twelve-year period the DoD could have saved roughly 100 million dollars per year on jet fuel had it hedged 100 percent of its' domestic fuel purchases. In addition, the DoD could have saved 1.2 billion dollars over the twelve-year period had it hedged all of its' jet fuel expense with heating oil futures. Hedging with futures would have yielded positive results 8 out of the possible 12 years used in this analysis. The largest loss occurred in FY98, in the 100 percent hedge scenario this would have been a loss of 181 million dollars. The greatest savings was realized in FY05, for the 100 percent scenario this savings totaled to 409 million dollar for the DoD. The total savings achieved would be more than enough to pay any additional overhead costs realized in order to execute the strategy.

Hedging with Call Options Results and Analysis

The call option models provided positive results as well; Table 8 shows the results of this analysis. Over the twelve-year period used for this analysis, hedge positions outperformed the historical DESC purchase price in every fiscal year.

Table 8. Annual Then Year Results of Hedging with Call Options

Fiscal Year	Hedge Position 25%	50%	75%	100%
96	$28,877,788	$57,755,576	$86,633,364	$115,511,152
96	$8,929,925	$17,859,850	$26,789,775	$35,719,700
96	$10,199,133	$20,398,265	$30,597,398	$40,796,531
96	$15,362,713	$30,725,427	$46,088,140	$61,450,854
00	$58,131,251	$116,262,502	$174,393,753	$232,525,004
01	$3,003,746	$6,007,491	$9,011,237	$12,014,982
02	$3,884,655	$7,769,309	$11,653,964	$15,538,618
03	$18,305,421	$36,610,842	$54,916,263	$73,221,684
04	$103,805,624	$207,611,248	$311,416,872	$415,222,495
05	$106,791,151	$213,582,302	$320,373,453	$427,164,604
06	$18,583,369	$37,166,739	$55,750,108	$74,333,478
07	$22,841,801	$45,683,603	$68,525,404	$91,367,206
Avg Savings	**$33,226,381**	**$66,452,763**	**$99,679,144**	**$132,905,526**

Once again, the greater the hedge positions the higher the savings for the DoD. In then-year terms, on average the DoD could have realized a 132.9 million dollar savings per year had it hedged all of its jet fuel purchases over the twelve-year period.

Table 9 shows the results of Table 8 in constant year 2000 dollars. Table 9 is similar to Table 7 in that it uses the GDP deflator to convert the then year dollars into constant year terms and it has a total row at the bottom of the table. Therefore, all of the results of this analysis are in constant year 2000 dollars.

Table 9. Annual Constant Year 2000 Results of Hedging with Call Options

Fiscal Year	Hedge Position 25%	50%	75%	100%
96	$31,352,776	$62,705,552	$94,058,328	$125,411,104
96	$9,514,901	$19,029,803	$28,544,704	$38,059,605
96	$10,689,346	$21,378,692	$32,068,038	$42,757,384
96	$15,924,531	$31,849,062	$47,773,593	$63,698,124
00	$59,397,608	$118,795,216	$178,192,824	$237,590,432
01	$3,003,746	$6,007,491	$9,011,237	$12,014,982
02	$3,793,645	$7,587,290	$11,380,935	$15,174,580
03	$17,569,774	$35,139,549	$52,709,323	$70,279,098
04	$97,558,009	$195,116,018	$292,674,027	$390,232,036
05	$97,560,022	$195,120,044	$292,680,065	$390,240,087
06	$16,440,513	$32,881,026	$49,321,539	$65,762,052
07	$19,577,121	$39,154,242	$58,731,362	$78,308,483
Total	**$382,381,992**	**$764,763,984**	**$1,147,145,976**	**$1,529,527,968**
Avg Savings	**$31,865,166**	**$63,730,332**	**$95,595,498**	**$127,460,664**

On average, over the twelve-year period the DoD could have saved 127.5 million dollars per year on jet fuel had it hedged 100 percent of its' domestic fuel purchases. This analysis also shows that the DoD could have saved 1.5 billion dollars over the twelve-year period had it hedged all of its jet fuel expense with heating oil call options. For the timeframe of this analysis, the DoD would have had positive returns for each FY. The smallest savings occurred in FY02, in the 100 percent hedge scenario the savings would have been a loss of 12 million dollars. The 100 percent hedge returned provided two year that realized 390.2 million dollars in savings. The savings realized would easily offset any additional cost realized by hiring the personal to implement the hedge or the transaction costs associated with the trade.

Both derivatives returned positive results for the DoD, with options outperforming futures by nearly 300 million dollars over the 12 year period. Future contracts have the potential to create the largest savings for the DoD but, they also come with the greatest amount of risk. Bearing that in mind, futures seem to be a good selection for a customer who is "risk loving". Options on the other hand are more appropriate for a customer who is risk adverse and as shown in the analysis, the payoffs are not as big but neither are the losses. The DoD in general is not a "risk loving" organization and tends to be risk adverse. This risk adverse mentality makes call options the ideal tool for the DoD to use when implementing a fuel hedge.

It is important to note that the results of this analysis reflect a timeframe in which the price of crude oil was generally rising. This upward trend in price undoubtedly affected the results of hedging with futures and options in a positive manner and needs to be recognized. However, since September 2008, the crude oil market has experienced a downward trend in price and this negative trend would affect the performance of hedging with each derivative differently. Buyers that used heating oil futures to make their hedge would be held to the purchase price of the heating oil futures contract and pay the agreed upon amount. Heating Oil futures closed for 2.84 dollars per gallon on 1 October 2008 and as of 18 February 2009, the price for heating oil futures is 1.14 dollars per gallon. Using futures in this instance would have cost a buyer 1.70 dollars more per gallon than simply purchasing fuel off the spot market. As we know, a buyer using options on the other hand would simply let their call expire and pay their premium. In the end, the call option buyer still benefits because the price of jet fuel has decreased with the price of crude oil and they are now paying a lower price for fuel than they had planned. Large negative price trends are rare for a high demand limited supply item such as crude oil. Negative price trends are not necessarily a bad thing, depending on the derivative used for creating a hedge, as one can still benefit from the price decline if options are used to create the hedge.

Options are the best selection for the DoD, but future contracts should not be completely ignored when creating a hedge. Undoubtedly, using an optimal mixture of options and futures to create the fuel hedge would be the dominant hedging strategy. This analysis looked at the market volatility in an attempt to uncover a pattern that would suggest using one derivative over the other.

Market Volatility Analysis

The premise for this analysis is that when faced with certain levels of market volatility one derivative would be preferential over the other for hedging. One characteristic of market volatility is the variance in price for that month. A large variance in price would indicate a highly volatile market for that month while a small variance in price would indicate a less volatile market.

This analysis used daily data obtained from the EIA to determine the monthly variance in price for heating oil futures from October 1995 to September 2007. The monthly variance in price was tested to see how strongly correlated it was with results from hedging with option and futures for the corresponding month. The results from this analysis indicate that there is a weak correlation between both of the derivatives and the variance in price. The correlation factor between price variance and the results from hedging with futures was 0.2496, while the correlation factor between price variance and the results for hedging with options was 0.2495.

Unfortunately, both of these correlation factors are weak and do not shed any additional light on the topic. In the end, price variance did not seem to matter when it came to derivative performance, even in the later years of the analysis when market volatility drove up the cost of call option premiums.

Quantity Hedged

Providing jet fuel price stability is the target goal of this analysis. With the positive results in hand, it is now time to determine how much fuel the DoD should hedge. To make this determination we are going to compare the results from hedging with futures and options to the projected DESC fuel cost for each FY used in this analysis. For this analysis the projected DESC cost will simply be the DESC standard price that is set at the beginning of the FY multiplied by the quantity of gallons purchased for the corresponding FY. By subtracting the cost for each hedge position from the projected DESC cost we will be able to determine if that hedge position would be sufficient in covering the projected DESC cost for the FY. Results from this analysis for futures are shown in Table 10.

Table 10. Future Hedge Position Cost vs Projected DESC Cost

Fiscal Year	Hedge Position 25%	50%	75%	100%
96	$ 657,300,657	$ 698,898,687	$ 740,496,718	$ 782,094,748
96	$ 184,865,851	$ 196,890,272	$ 208,914,694	$ 220,939,115
96	$ 1,069,201,029	$ 1,025,923,437	$ 982,645,845	$ 939,368,253
96	$ 885,111,024	$ 881,378,316	$ 877,645,609	$ 873,912,901
00	$ 52,608,584	$ 139,835,484	$ 227,062,384	$ 314,289,284
01	$ 664,286,097	$ 666,790,925	$ 669,295,754	$ 671,800,582
02	$ 597,460,198	$ 590,180,568	$ 582,900,939	$ 575,621,310
03	$ 22,772,726	$ 58,377,477	$ 93,982,229	$ 129,586,981
04	$ (159,244,520)	$ (55,894,893)	$ 47,454,734	$ 150,804,361
05	$ (269,040,607)	$ (157,018,241)	$ (44,995,875)	$ 67,026,491
06	$ 156,773,040	$ 124,887,645	$ 93,002,250	$ 61,116,855
07	$ 489,418,720	$ 490,864,085	$ 492,309,449	$ 493,754,813
Avg Savings	**$ 362,626,067**	**$ 388,426,147**	**$ 414,226,227**	**$ 440,026,308**

Positive numbers indicate that hedge position was sufficient in covering the projected DESC cost for that FY while negative numbers indicate the contrary. The results of this analysis indicate that hedging 100 percent of the domestic fuel purchase with futures would have been sufficient each year to cover the projected DESC cost. The 100 percent hedge position was able to consistently outperform the projected DESC cost in this analysis because the DESC standard price for jet fuel was higher than the spot market price that was used for the results in Table 6. Therefore, even though the costs for the 100 percent hedging position were higher than the market price, they were still lower than the projected DESC cost. The results from this analysis for the call option model are shown in Table 11.

Table 11. Call Option Hedge Position Cost vs Projected DESC Cost

Fiscal	Hedge Position			
Year	**25%**	**50%**	**75%**	**100%**
96	$ 644,580,414	$ 673,458,202	$ 702,335,990	$ 731,213,778
96	$ 181,771,354	$ 190,701,279	$ 199,631,205	$ 208,561,130
96	$ 1,122,677,754	$ 1,132,876,887	$ 1,143,076,019	$ 1,153,275,152
96	$ 904,206,444	$ 919,569,158	$ 934,931,871	$ 950,294,585
00	$ 23,512,935	$ 81,644,186	$ 139,775,437	$ 197,906,688
01	$ 664,785,015	$ 667,788,760	$ 670,792,506	$ 673,796,252
02	$ 608,624,482	$ 612,509,136	$ 616,393,791	$ 620,278,446
03	$ 5,473,395	$ 23,778,816	$ 42,084,237	$ 60,389,658
04	$ (158,788,522)	$ (54,982,899)	$ 48,822,725	$ 152,628,349
05	$ (274,271,822)	$ (167,480,671)	$ (60,689,519)	$ 46,101,632
06	$ 207,241,804	$ 225,825,174	$ 244,408,543	$ 262,991,913
07	$ 510,815,157	$ 533,656,959	$ 556,498,760	$ 579,340,561
Avg Savings	**$ 370,052,368**	**$ 403,278,749**	**$ 436,505,130**	**$ 469,731,512**

The results from this analysis are similar to the futures results in that only 100 percent hedge position consistently outperforms the projected DESC cost. Both comparison models show consistent average savings and indicate that either derivative could be used to provide stable fuel costs for the DoD.

Chapter Summary

In this chapter, we showed that hedging with both types of derivatives would have provided savings for the DoD. In comparison, call options provided a larger savings for the DoD than the futures did over the twelve-year period. Specifically, in constant year terms hedging with call options averaged nearly 27.5 million dollars per year more than hedging with futures. Additionally, the call option model grossed nearly 300 million more in savings than the futures model over the twelve-year period.

V. Conclusions

Explanation of the Problem

Since 2003, the price of jet fuel has been very volatile and difficult for OMB to forecast accurately. These two factors have created an environment in which a DESC standard price for jet fuel is not stable. With the component services relying heavily on the DESC standard price for budgetary purposes, changes to the standard price during the fiscal year creates financial havoc for the DoD. These times of financial hardship force the services to seek supplemental funding from congress to stay mission ready. The models provided in this paper offer a "what if" the DoD had entered into a fuel hedge analysis. This analysis provides DoD leadership with sound historical based analysis to support the use of implementing a fuel hedging position to mitigate financial losses due to increasing jet fuel prices. This mitigation of financial loss will help alleviate the financial drain placed on the DESC and enable the creation of a stable standard price for jet fuel.

Restatement of Results

The results of this analysis indicated that the DoD would benefit from undertaking a hedging position by realizing a reduction in cost for jet fuel purchases. Overall both derivative instruments yielded positive results but the call option models constantly delivered positive returns for the DoD, indicating that call options are the dominant hedging instrument between the two selections. The DoD should consider utilizing either of the aforementioned derivatives to create a fuel hedge for future use.

Recommendations

We recommend that the DoD consider a pilot program that uses call options to hedge a portion of their jet fuel expense. Since this would be a pilot program, we recommend that the DoD hedge 25 percent of its domestic fuel consumption in order to test the viability of the program. This 25 percent hedge would only be equal to roughly 12.5 percent of the DoDs total jet fuel consumption because DESC only purchases roughly 50 percent of DoDs fuel on the domestic market. Although the results of this analysis indicate that only the 100 percent hedge position consistently outperform the projected DESC cost, it is our belief that the DWCF would sustain the minor losses that occur in the 25 percent hedge position. With all of the data available from this pilot program, the DoD would be in a better position to determine if they wanted to continue with the hedging program or in-fact increase the size of the hedge to reduce their exposure even further for future purchases.

Limitations

There are several limitations to using an ex post facto analysis. Making a causal statement between the implementation of a fuel hedging position and budgetary stability for the DoD is one of those limitations. Past performance in no way predicts future results. Over the twelve year period of this analysis, hedging positions based off futures and call options yielded financial savings for the DoD, but this does not mean these type of hedging positions will always create financial savings in the future. The price of jet fuel tracks the price of crude oil and the only thing that has been consistent about the price of crude is that it is constantly changing. As fast as the price of oil rose from 2003 to 2008, it fell even faster in late 2008 by dropping nearly 100 dollars per barrel in three months. This rapid decrease in price could have created a situation in which a fuel hedge based off either derivative would return a loss for the DoD.

Another important item to note in this analysis is that when hedging using options, in no case was 100 percent of the data available to create a historical hedge based solely off call options. As mentioned earlier, this analysis used the closest strike price to the "at the money" position to create the hedge. However, there were instances when no strike price available for a month and the analysis used the historical DESC weighted price for those occurrences. Despite these shortcomings, the data clearly indicates that a passive hedging strategy using futures or call options would have produced positive results over the twelve-year period.

Recommendations for Future Research

The results of this research are very self-explanatory and leave little room for additional research except for two areas. A thorough evaluation of the federal laws that govern or restrict this type of program is required. This paper identified the major legal obstacle preventing the DoD from implementing a hedging program but, it did not cover the matter in extensive legal detail. With the positive results of this research in hand, a focused look into the legal matter is justified.

Additional research is needed to uncover the optimal mixture of derivatives to be used when creating a fuel hedge for the DoD. Similar to an investment portfolio, a fuel hedge should have some diversity. This diversity could involve using call option and futures contracts based off of heating oil and crude oil. The commercial sector uses both commodities to create fuel hedges and this avenue could be explored for the DoD as well.

Bibliography

Air Force Cost Analysis Agency, Flying Hour Factors Division. (2007). Air Force Cost Analysis and Performance Tool.

Alexander, K. (2004, June 3). *Airlines Fuel Prices Tough to Swallow*. Retrieved August 2008, from Washington Post: http://www.washingtonpost.com/wp-dyn/articles/A11303-2004Jun2.html

Buffett, W. (n.d.). *Warren Buffett Quotes*. Retrieved November 2008, from Brainy Quote: http://www.brainyquote.com/quotes/authors/w/warren_buffett.html

Chinn, M., Le Blanc, M., & Corbion, O. (2001, October). *The Predictive Characteristics of Energy Futures: Recent Evidence for Crude Oil, Natural Gas, Gasonline and Heating Oil*. Retrieved October 2008, from Social Science Research Network: http://papers.ssrn.com/sol3/papers.cfm?abstract_id=288844

CME. (2006). *An Introduction to Futures and Options*. Retrieved May 2008, from Chicago Mercantile Exchange: http://www.cme.com/files/intro_fut_opt.pdf

Cobbs, R., & Wolf, A. (2004, May). *Jet Fuel Hedging Strategies: Options Available for Airlines and a Survey of Industry Practices*. Retrieved February 2008, from Kellogg School of Management, Northwestern University: http://www.kellogg.northwestern.edu/research/fimrc/papers/jet_fuel.pdf

Defense Business Board. (2004, March 1). *Fuel Hedging Task Group*. Retrieved July 2008, from Defense Link: http://www.dod.mil/dbb/pdf/FuelHedging-03-2004.pdf

DESC. (2008). *DESC Fact Book*. Retrieved June 2008, from Defense Energy Support Center: http://www.desc.dla.mil

Edwards, M. (2008). *Strategies for Minimizing Monetary Loss in the Department of Defense Budget through Use of Financial Derivatives*. AFIT.

EIA. (2008). *Annual Energy Outlook*. Retrieved November 2008, from Energy Information Adminstration: http://www.eia.doe.gov/oiaf/aeo/aeoref_tab.html

Gaffen, D. (2008, April 28). *Airlines Caught Un-Hedged*. Retrieved September 2008, from The Wall Street Journal: http://blogs.wsj.com/marketbeat/2008/04/23/airlines-caught-un-hedged/

GAO. (2002). *Better Fuel Pricing Practices will Improve Budget Accuracy*. Retrieved from Government Accountability Office: http://www.gao.gov/new.items/d02582.pdf

GAO. (2004, January). *Principles of Federal Appropriations Law, Third Edition, Volume 1*. Retrieved November 2008, from Government Accountability Office: http://www.gao.gov/special.pubs/d04261sp.pdf

Garven, J. (2004, July 16). *Impact of High Fuel Prices*. Retrieved June 2008, from Options, Futures and other Derivatives: http://129.62.162.212/weblogs/ofod/archives/week_2004_07_11.html

Groshek, G., & Felli, J. (2000). Foreign Exchange and Lost Opportunity in the US Department of Defense. *Multinational Financial Management* .

Knapp, J. (March, 2008). Should the Department of Defense Hedge Oil Prices In Order To Save Money.

Lorenz, S. (2005, September 13). *Inside the Air Force Budget*. Retrieved June 2008, from Air Force Association: http://www.afa.org

NYMEX. (2007). *Energy Complex.* Retrieved March 2008, from New York Mercantile Exchange: http://www.nymex.com/media/EnergyComplex.pdf

NYMEX. (2007). *Principles of Hedging and Price Discovery*. Retrieved March 2008, from New York Mercantile Exchange: http://www.nymex.com/ehedge.aspx?pg=2#2

Ogg, J. (2007, October 18). *Southwest Losing its Hedge.* Retrieved from The Wall Street Journal: http://www.247wallst.com/2007/10/southwests-fuel.html

OSD. (2006). *The Benefits of the Defense Working Capital Fund.* Retrieved from Office of the Secretary of Defense Comptroller: http://www.dod.mil/comptroller/icenter/dwcf/benefits.htm

Reuters. (2008, August 5). *UPDATE 1-Big CFTC data revision raises oil traders' eyebrows*. Retrieved September 2008, from Reuters: http://www.reuters.com/article/governmentFilingsNews/idUSN0535661120080805

SEC. (2006, January 4). *Southwest SEC Filing Statement.* Retrieved August 2008, from United States Securities and Exchange Commission: http://sec.edgar-online.com/2000/03/28/13/0000950134-00-002530/Section10.asp

Spinetta, L. (2004, October). *Fuel Hedging, Lessons from the Airlines.* Retrieved from Air Force Journal of Logistics: http://www.aflma.hq.af.mil/lgj/4_hedging.pdf

Stulz, R. (1996). Rethinking Risk Management. *Journal of Applied Corporate Finance* , 8-24.

University of Minnesota. (2007, October 12). *Options, Futures and Derivatives.* Retrieved November 2008, from Mechanics of Futures Market: http://www.math.umn.edu/~spirn/5075/Lecture3.pdf

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 074-0188

1. REPORT DATE *(DD-MM-YYYY)*	**2. REPORT TYPE**	**3. DATES COVERED** *(From – To)*
26-03-2009	Master's Thesis	Jun 2008 to Mar 2009

4. TITLE AND SUBTITLE
Jet Fuel Hedging Strategies for the Department of Defense Through use of Financial Derivatives

5a. CONTRACT NUMBER

5b. GRANT NUMBER

5c. PROGRAM ELEMENT NUMBER

6. AUTHOR(S)
Gibson, William T., Capt, USAF

5d. PROJECT NUMBER
N/A

5e. TASK NUMBER

5f. WORK UNIT NUMBER

7. PERFORMING ORGANIZATION NAMES(S) AND ADDRESS(S)

Air Force Institute of Technology
Graduate School of Engineering and Management (AFIT/EN)
2950 Hobson Way
WPAFB OH 45433-7765

8. PERFORMING ORGANIZATION REPORT NUMBER
AFIT/GCA/ENV/09-M04

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)

Stephen E. Connair, GS-15, USAF
Office of the Assistant Secretary of the Air Force for Economics and Business Management
1130 Air Force Pentagon
Washington, D.C. 20330-1130
(703) 697-1152

10. SPONSOR/MONITOR'S ACRONYM(S)
SAF/FMCE

11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
APPROVED FOR PUBLIC RELEASE; DISTRIBUTION UNLIMITED

13. SUPPLEMENTARY NOTES

14. ABSTRACT
The primary purpose of this research is to assess the practicality of utilizing some of the financial derivative products available on the market today in an effort to mitigate monetary losses due to the increasing price of jet fuel, thereby increasing stability in the DOD budget. The scope of this research will focus on the use of futures and call option contracts. Domestic jet fuel expenditure data was collected for Fiscal Years 1996 to 2007 and cross-referenced with the contract process of the previously mentioned financial hedging instruments during the same period of time. Results from the ex post facto analysis indicate that hedging with either heating oil futures or heating oil call options would have provided a tremendous overall savings to the DOD. Currently the DOD does not hedge its budget against fluctuation in the jet fuel spot market. The implication from this study is that the DOD should consider hedging its jet fuel exposure with either derivative, in particular call options as it is tailored for risk adverse customers.

15. SUBJECT TERMS
Jet Fuel Hedging, Financial Derivatives

16. SECURITY CLASSIFICATION OF:			**17. LIMITATION OF ABSTRACT**	**18. NUMBER OF PAGES**	**19a. NAME OF RESPONSIBLE PERSON**
a. REPORT	**b. ABSTRACT**	**c. THIS PAGE**			Major Todd Peachey
U	U	U	UU	61	**19b. TELEPHONE NUMBER** *(Include area code)* 937-255-3636 ext 7391

Standard Form 298 (Rev. 8-98)
Prescribed by ANSI Std. Z39-18

Form Approved
OMB No. 074-0188