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Does Hedging Success Matter? An Empirical Study of Jet Fuel Hedging in the U.S. Airline Industry

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by

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ABSTRACT

Airlines commonly employ hedging as a risk management strategy to protect themselves against sudden, unpredictable increases in the price of jet fuel. In a seminal paper by Carter, Rogers, and Simkins (2006), it is established that jet fuel hedging by airlines increases the firm value of the airline. This dissertation replicates their study using an expanded dataset over a greater period of time. This study finds a smaller "hedging premium" than Carter, Rogers, and Simkins (2006). It is shown that the leasing of aircraft plays an important role in the relationship between the hedging premium and capital expenditures.

The measure of jet fuel hedging used in the previous studies, the percentage of next year's fuel requirements hedged, accounts for the amount of hedging done by the airline, but it does not consider the performance of the jet fuel hedges. This dissertation for the first time determines the effect of jet fuel hedging performance, as measured by the realized gains and losses from jet fuel hedging, on the value of the firm. The analyses find that the realized gains and losses have a negative relationship with firm value. However, after identifying outliers (such as the significant hedging losses in 2009 resulting from falling jet fuel prices during the financial crisis) using a simple box plot and removing them from the sample, realized gains and losses show a positive correlation with firm value.

Furthermore, successful hedging may induce principal-agent issues such as buying market share behavior. When an airline experiences a run of hedging success, a manager may mistakenly believe that the cost of jet fuel is decreasing. This is not the case, however, as the cost of using jet fuel is the price that can be received selling it on the open market, not the price paid for the jet fuel. A manager may attempt to pass on the “savings” to consumers in the form of lower fares, lowering the price below its profit-maximizing level. This in turn can increase the airline’s market share, although it comes at the expense of reduced profit. This dissertation tests the relationship between successful jet fuel hedging and market share. A positive and statistically significant correlation between successful hedging and market share is found for Southwest Airlines and American Airlines, two carriers known for successful hedging, but statistically insignificant results for smaller carriers Alaska Airlines and JetBlue Airways.

CHAPTER ONE:

INTRODUCTION

1.1 Background on Jet Fuel Price Hedging

One of the most significant challenges facing airlines is reducing jet fuel price risk. This size of this risk comes from two sources: 1) jet fuel prices tend to be highly volatile and 2) jet fuel expenses make up a large and increasing portion of an airline's total operating costs.[1] Taken together, even small increases in the price of jet fuel can result in substantially higher jet fuel expenses. Southwest determined in 2008 that a one cent increase in the price of jet fuel would result in an additional $15 million in fuel expense (Southwest, 2008). Larger increases in fuel prices would have an even more significant impact. In 2002, when jet fuel prices were comparatively low, American Airlines estimated that a 10% increase in the price of jet fuel would increase their total fuel expense by $169 million (AMR, 2002). By 2008, when jet fuel prices reached an all-time high, a 10% increase in the jet fuel price would increase American Airlines' total fuel expense by $649 million (AMR, 2008). Given the large impact that moderate jet fuel price increases can have on total fuel expense, it is imperative that airlines minimize jet fuel price risk whenever possible.

[1] Figure 1.1 shows the US Gulf Coast jet fuel prices WTI crude oil prices from April 1990 to April 2018. The volatility of jet fuel prices (as measured by the standard deviation) increased 6.41 dollars per barrel from 1992 to 2003 to 29.47 dollars per barrel from 2004 to 2014. Table 1.1 displays the percentage of jet fuel expenses to total operating costs from 2001 to 2014 for six major airlines. Jet fuel expenses increase from an average of 15% of total operating costs in 2001 to over 35% in 2014.

The most common risk management activity airlines use to decrease jet fuel price risk is through hedging. Airlines typically hedge by purchasing financial derivatives contracts, such as call options or swaps. The purpose of these contracts is to set an effective upper limit on the price of jet fuel for the amount fuel hedged (airlines will only hedge a portion of their jet fuel requirements if they choose to hedge). If the market price of jet fuel rises above this upper limit then the airline only pays the lower, agreed upon price in the derivative contract for the amount of fuel hedged. This reduces the volatility of the price of jet fuel for the hedging airline.

1.2 An Economic Perspective of Hedging and Firm Value

Just as increases in the price of jet fuel can have a significant, detrimental effect on an airline's jet fuel expenses, an airline that hedges a substantial amount of its jet fuel can realize a considerable reduction in its accounting costs when jet fuel prices are high. It is vitally important to note, however, that hedging the price of jet fuel does *not* reduce the economic cost of using it. The economic cost of using jet fuel is the value of the jet fuel by selling it on the open market, not the original price paid for it. Economic costs are invariant to whether or not an airline hedges jet fuel. As a result, hedging will also not influence a profit-maximizing airline's output or pricing decisions. For jet fuel hedging to increase the value of the firm, it must come from source separate from reducing the economic cost of using the fuel.

How hedging can influence value can be determined by analyzing the economic definition of the value of the firm. A typical definition of the value of the firm is the net present value of discounted expected economic profits over the life of the firm. Mathematically, this can be expressed in the following way.

$$V = V_0 + \sum_{t=1}^{T} \frac{E(\pi_t)}{(1+r)^t} \quad (1)$$

where V is firm value (V_0 is the firm's initial value at time zero), r is the discount rate (i.e., the cost of capital), π is economic profit at time t through the end period T. For hedging to increase firm value, it must increase expected profit in some time periods or the cost of capital must be reduced.

The current literature on hedging suggests that reducing the volatility of a firm's earnings with hedging can increase expected profit despite the hedges themselves having zero or negative expected value.[2] First, firms with convex tax functions in income will have a smaller tax liability when the variability in pre-tax income is reduced. Second, lowering the firm's income variability will can decrease the probability that the firm will experience financial distress or bankruptcy, both of which can be exceptionally costly to firms. Lowering expected distress or bankruptcy costs can increase expected profit.

Hedging may also reduce the cost of capital. Without hedging, the primary way for a firm to obtain the funds necessary for capital investment, especially when cash flows are low, is through external financing. However, borrowing funds in this way comes with interest rate risk and increased scrutiny from lenders. This increases the minimum rate of return needed for the firm to invest in value-increasing projects. Hedging can allow firms to increase the level of internal funds available for investment without having to rely on costly borrowing. This in turn reduces the cost of capital and increases the number of investment projects that the firm can profitably fund.

[2] Most financial derivatives that firms use to hedge are not costless. Call options, for example, have a premium that the hedging firm must pay to the other counterparty selling the call. The expected value of such an instrument will be negative.

1.3 Contributions to the Literature

This dissertation improves on the economic literature in two ways. The first contribution is to the general hedging literature. For the first time, the success of an airline's jet fuel hedging activities, as measured by the airline's gains and losses from its jet fuel hedges, is included as a determinant of firm value. Previous studies only consider the amount of hedging done as a percentage of total expected fuel requirements. All else equal, airlines that hedge more jet fuel expect to have higher firm values. However, this does not take into account whether or not the jet fuel hedges themselves are successful. Airlines with realized gains on these hedges will be able to use the increased cash flow to fund additional investments that unsuccessful hedging airlines cannot. The hedging premium is evaluated during periods when airlines experience successful jet fuel hedges.

The second contribution the dissertation will add is to the antitrust literature. Thomas and Kamp (2006) argue that when corporate controls are weak, managers may choose price below marginal cost in order to gain market share, even if such behavior in contrary to the assumption of profit maximization. Airlines that are successful with their jet fuel hedges may choose to use the "savings" from hedging to lower airfares. This in turn may allow the airline to claim increased market share. Tufano (1998) acknowledges this possibility when he suggests that hedging may decrease firm value if managers use the additional cash flows from hedging to finance investment projects that increase the manager's wealth but are value-destroying projects for the firm. Airlines that show behavior consistent with "buying market share" may be of interest to antitrust officials.

1.4 Organization

The remainder of the dissertation chapters will have the following structure. Chapter two provides a detailed discussion of the hedging literature. The first section starts with the theoretical models developed to explain the factors that contribute to a firm's decision to hedge and the possible mechanisms by which hedging increases the value of the firm. The second section samples important empirical analyses of these theories on interest rate, foreign currency, and output price hedging. The third section describes studies of input price hedging in which airlines hedge against jet fuel prices. This literature has primarily been driven by collaboration between David Carter, Daniel Rogers, and Betty Simkins, beginning with their 2006 paper on the effect of jet fuel price hedging on firm value. They examine the economic and financial variables that influence airlines' hedging decisions, the effect of the amount of hedging they engage in on the value of airlines, and the possible sources of the increase in value. Other studies focus on how airlines' jet fuel price risk exposure affect the decision to hedge. The final section offers a brief overview of commodity price hedging and possible avenues of future research.

Chapter three describes each data source, the variables contained within each source, and variable collection and calculation methods. Non-hedging financial data and executive compensation data come from Wharton Research Data Services' Compustat and Execucomp databases, respectively. Hedging data are taken from airline 10-K and 10-K405 statements retrieved from the Electronic Data Gathering, Analysis, and Retrieval system. This database is maintained by the Security and Exchange Commission. Examples are provided directly from airline 10-K statements explaining how to determine expected future jet fuel requirements hedged and jet fuel hedging gains and losses. Finally, passenger data and ticket price information for each airport are taken from the T-100 Databank and the DB1B survey, respectively. Methods of passenger aggregation by city-pair market are discussed as well as calculation of market share for each airline in a market. Ticket prices are measured using the itinerary yield instead of fares to control for the length of a flight (longer flights have higher fares).

The fourth chapter of the dissertation achieves two objectives. The first goal is to perform a similar analysis of jet fuel hedging as done by Carter, Rogers, and Simkins (2006) over a broader and more recent sample period (1992 to 2003 in the initial study compared to 1995 to 2014 in this analysis). In the current time period, risk exposure is significantly larger than in previous time frame. Financial constraints are found to reduce, not increase, the amount of hedging done by airlines. The hedging premium is generally smaller across different econometric models. It is found that capital expenditures have a positive effect on firm value through hedging when considering lease adjusted variables over one-stage and two-stage estimation methods. Finally, yearly hedging premiums are found to be positive and statistically significant when jet fuel prices are highly volatile.

The second aim of the chapter is to determine the effect of jet fuel hedging success, as measured by an airline's realized gains and losses from its jet fuel hedging contracts on firm value. A positive relationship between jet fuel hedging success and firm value is expected, however, a statistically significant negative correlation is found. This may be because of outliers from Southwest's unprecedented jet fuel hedging success from 2004 to 2008, and the significant losses all airlines suffered in 2009. Estimating the model after eliminating these outliers from the sample results in a positive, though statistically insignificant, relationship between jet fuel hedging gains and losses and firm value.

Chapter five discusses how successful jet fuel hedging can affect an airline's business decisions regarding expansion versus bolstering markets where the airline already operates. Airlines with increased cash flows from jet fuel hedges may choose to return the savings to shareholders as dividends, lower their ticket fares to increase market share in existing markets, or choose to enter new markets. A simple model is used to test the correlation between positive jet fuel hedging gains and market share (share of passengers flown by an airline in a market relative to the total number of passengers flown across all airlines in the market). The primary airline studied is Southwest Airlines because of their significant jet fuel hedging gains in the early to mid-2000s followed by hedging losses after 2009. A positive and statistically significant relationship is found between positive hedging gains and market share across multiple market restrictions and definitions.

Chapter six concludes the dissertation by discussing the primary findings and contributions to the hedging and antitrust literature made by this dissertation. Three contributions are made in chapter four. First, jet fuel hedging gains and losses are found to have a negative and statistically significant effect on firm value. However, this relationship becomes positive after the elimination of outliers from the sample. Second, the section regarding the determinants of jet fuel hedging find a negative relationship between financial constraint variables and the amount of jet fuel hedging. This provides more evidence that suggests financially constrained firms hedge less, not more. Third, a positive association between capital expenditures and the hedging premium is found when accounting for aircraft leases. Without adjusting for leases, the correlation is negative and statistically insignificant. This shows that investing in leased aircraft is an important component of the additional value airlines can gain from capital expenditures.

The primary contribution in chapter five is finding a positive and statistically significant relation between successful jet fuel hedging and changes in market share for Southwest Airlines. Although this does not suggest that Southwest is necessarily buying market share, it does show that further investigation is warranted.

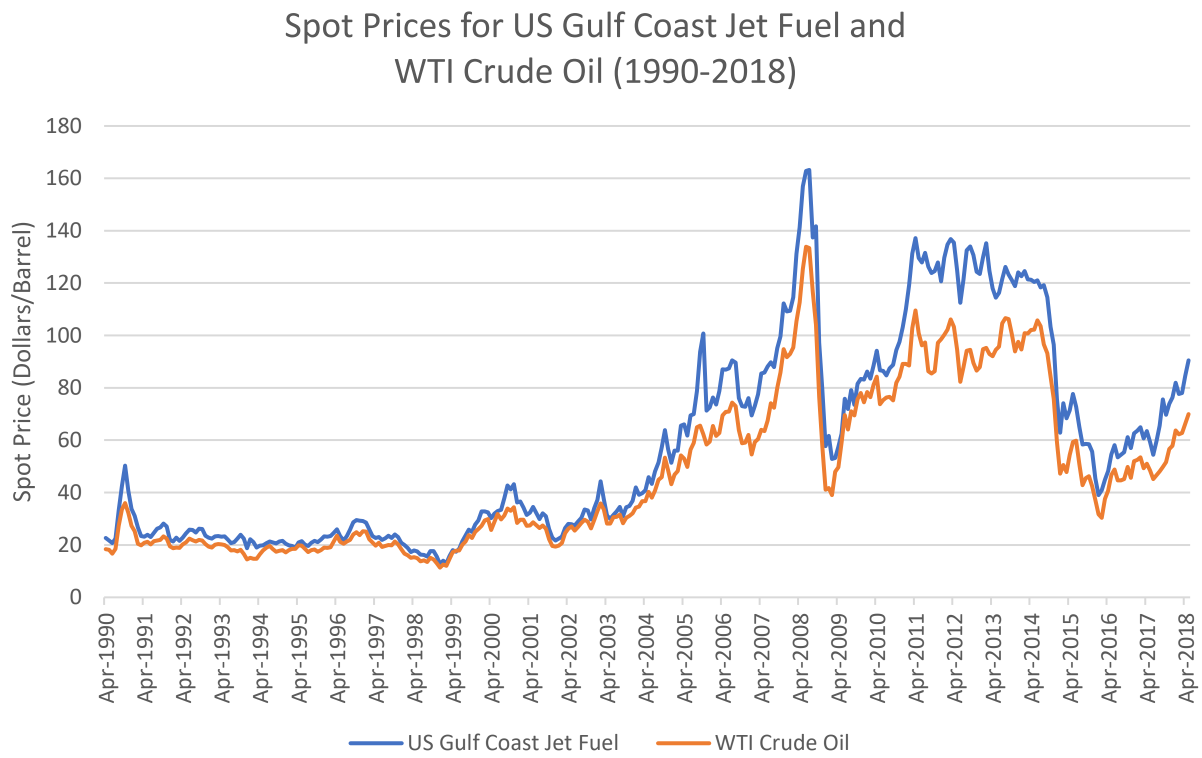

Figure 1.1: Spot Prices for US Gulf Coast Jet Fuel and WTI Crude Oil

Notes: This graph shows the spot prices for US Gulf Coast Jet Fuel and WTI Crude Oil from April 1990 to May 2018 in dollars per barrel. Jet fuel spot prices were converted from dollars per gallon to dollars per barrel by multiplying dollars per gallon by 42. Source: Energy and Information Administration, https://www.eia.gov/.

Table 1.1: Yearly Jet Fuel Expense as a Percent of Total Operating Expense

Year	Airline						Average
	American	Alaska	Delta	JetBlue	Southwest	United	
2001	14.87%	15.77%	13.25%	14.71%	16.89%	14.19%	14.95%
2002	13.81%	14.26%	12.89%	15.09%	16.21%	12.00%	14.04%
2003	16.44%	16.14%	14.89%	18.76%	16.53%	14.87%	16.27%
2004	22.70%	21.53%	19.20%	23.50%	18.26%	18.03%	20.54%
2005	28.87%	25.60%	26.64%	31.55%	21.49%	24.11%	26.38%
2006	31.47%	28.64%	27.50%	35.61%	28.00%	31.36%	30.43%
2007	32.06%	28.24%	27.88%	37.06%	29.87%	32.47%	31.26%
2008	38.76%	39.43%	34.46%	43.73%	37.26%	42.58%	39.37%
2009	28.25%	22.94%	27.92%	33.76%	32.36%	27.68%	28.82%
2010	30.67%	28.90%	27.55%	34.63%	34.53%	32.61%	31.48%
2011	35.60%	36.22%	31.01%	42.05%	40.03%	37.33%	37.04%
2012	37.22%	37.79%	31.25%	41.26%	39.64%	38.34%	37.58%
2013	37.71%	36.24%	35.48%	39.94%	37.26%	35.45%	37.01%
2014	34.94%	34.23%	37.88%	37.91%	34.56%	33.93%	35.58%

Notes: This table shows the yearly jet fuel expense as a percentage of total operating expense from 2001 to 2014 for six major United States airlines and the overall average for all six airlines.

CHAPTER TWO:

LITERATURE REVIEW OF JET FUEL HEDGING IN THE AIRLINE INDUSTRY

2.1 Introduction to the Hedging Literature

People and firms have used hedging as a financial and economic tool to protect against economic uncertainty for centuries. As noted by Smith and Stulz (1985, p. 391), hedging strategies employed by firms had been well documented in the literature previous to their work. However, the effect that hedging has on firm and industry performance had received very little academic scrutiny up to that point. Since the publication of their work, the role of hedging on firm behavior and performance has become a topic of significant theoretical and empirical interest.

2.1.1 Theoretical Hedging Literature Overview

The theoretical hedging literature asks several fundamental questions: What firm characteristics affect the firm's decision or ability to hedge or not? If the firm does hedge, how much does it hedge? How does hedging affect the value of the firm? To what extent does a hedging firm affect its value compared to a non-hedging firm? The theories developed to answer these questions are separated into multiple categories. Financial constraint theories determine how firms approach their hedging decisions when they are in financial distress (or simply in danger of entering distress). Smith and Stulz (1985) and Rampini, Sufi, and Viswanathan (2014) are the major theoretical studies that deal with the hedging behavior of financially distressed firms. Firms facing severe financial constraints may suffer from underinvestment, that is, firms with insufficient leverage may be unable to secure external financing to fund profitable investment projects. Such firms may hedge more to increase internal cash flows, allowing for profitable investment and increasing the value of the firm. Froot, Scharfstein, and Stein (1993) primarily explores this underinvestment theory of hedging.

The tax structure of the firm also plays a role in a firm's decision to hedge and hedging's impact on value. Smith and Stulz (1985) explain that firms with convex tax functions with respect to value can expect higher firm values when hedging as a result of reduced expected tax liability. The degree of tax function convexity may influence the amount of hedging engaged in by firms to take advantage of a reduced expected tax liability. Finally, Smith and Stulz (1985) show that managerial compensation may affect hedging decisions. Firms have an incentive to offer managerial compensation packages whose incentives align with those of the firm. Otherwise, the firm may create agency problems if compensation incentives do not match the firm's objectives.

2.1.2 Empirical Hedging Literature Overview

Numerous empirical studies have been performed to test hypotheses developed in the theoretical hedging literature. These studies cover multiple industries and different sources of risk (e.g., commodity prices, foreign currencies, interest rates, etc.). For example, Tufano (1996) analyzes gold price hedging by gold mining firms, Haushalter (2000) and Jin and Jorion (2006) observe output price hedging by oil and gas firms, Carter, Rogers, and Simkins (2006) investigate jet fuel hedging by airlines, and Allyannis and Weston (2001) evaluate foreign currency hedging by nonfinancial firms.

The analyses that evaluate the factors that influence firm hedging decisions find that financial constraints and managerial compensation are the most important determinants of hedging by firms while tax considerations are generally insignificant. Studies on the effect of hedging on firm value show mixed results. Allyannis and Weston (2001) and Carter, Rogers, and Simkins (2006) both find a positive relationship between hedging and firm value while Jin and Jorion (2006) determine no statistical effect.

2.1.3 Jet Fuel Hedging Literature Overview

One of the seminal papers in the hedging literature is the Carter, Rogers, and Simkins (2006) study of jet fuel hedging in the airline industry. They find that the airline industry fits the underinvestment framework of Froot, Scharfstein, and Stein (1993) because of airlines high distress costs and positive relationship between investment and jet fuel prices. They evaluate the determinants of jet fuel hedging by airlines and the effect that jet fuel hedging has on the value of the airline. Finally, they show that the source of value from hedging comes capital expenditures which is again consistent with the Froot, Scharfstein, and Stein (1993) theory of hedging.

Further studies of jet fuel hedging in the airline industry investigate jet fuel hedging by using operational hedging (Treanor, et al., 2014a). This is primarily done by using more fuel-efficient aircraft and maintaining a diverse fleet by aircraft size. Treanor, et al. (2014b) evaluate how airline adjust their jet fuel hedging behavior as the jet fuel price exposure of changes and estimate the effect of jet fuel hedging on firm value over different levels of jet fuel price exposure.

The remainder of the literature review is structured as follows. Section 2.2 provides greater detail of the theoretical hedging literature and possible discrepancies in different theories.

Section 2.3 discusses the empirical literature of hedging and how the results of the studies comport with the theories described in section 2.2. Section 2.4 focuses on studies of jet fuel hedging in the airline industry, what influences jet fuel hedging decisions, and how it affects the value of the firm. Section 2.5 offers suggestions on further avenues of research proposed by Carter, et al. (2017).

2.2 Theoretical Literature: Hedging and Firm Value

Firms use hedging as a way to reduce risk due to unexpected fluctuations in different kinds of economic variables. Smith and Stulz (1985) define hedging as a reduction in the dependence of firm value on changes in a state variable. Vasigh, Fleming, and Humphries (2014) define the objective of hedging as the reduction or minimization of price risk resulting from uncertainty in future price levels. Firms typically engage in hedging by buying or selling financial derivatives such as future contracts, forward contracts, options (input price hedgers will generally use call options, output price hedgers will generally use put options), and swaps.

Since financial derivatives that firms use to hedge against input price risk have zero expected value, and investors can hold diversified portfolios to avoid higher rates of risk, one can sensibly ask how engaging in hedging can have a non-zero effect on firm value? Modigliani and Miller (1958) show that the value of the firm is independent of the capital structure used to finance the firm. This is true, however, only when markets are efficient and there are no taxes, financial distress costs, agency costs, or asymmetric information, none of which are generally true in practice. Several theories have been introduced to explain how the existence of these market imperfections allow hedging to increase firm value.

The first model was established by Smith and Stulz (1985), where they argue that hedging can increase firm value through various avenues. First, hedging can reduce expected tax payments. If a firm's tax schedule is convex in tax rates, and hedging can reduce the variation in its pre-tax value, then its expected post-tax value will be increased. However, if transaction costs due to hedging outweigh the gain in expected post-tax value, or if the investors who allow firms to hedge have non-linear tax rates which increases the cost of hedging, then hedging may have no effect or reduce the expected post-tax value of the firm (see Figure 1). Second, hedging can increase firm value by reducing the probability of financial distress or bankruptcy, thereby reducing expected transaction costs due to financial distress. Since bankruptcy and financial distress costs are a decreasing function of pre-tax firm value, then by reducing the variability in pre-tax firm value through hedging, the firm can increase its post-tax value. Third, hedging can increase firm value if it reduces the compensation given to managers while still encouraging managers to hedge by aligning their compensation packages with the interests of the firm. This requires that managers' compensation packages are an increasing and concave function of end-of-period firm value.

Following the work of Smith and Stulz (1985), an extension of the theory was developed by Froot, Scharfstein, and Stein (1993) in which they argue that firms can increase firm value by avoiding underinvestment issues through hedging. Since hedges will reduce the variability in cash flows, it can increase the amount of cash held by firms in low-cash states, allowing firms to fund investment projects that they may not have been able to finance otherwise. Tufano (1998) notes that additional investment projects may not increase firm value if the quality of the projects being funded is poor. This possibility may arise if the welfare of managers conflicts with the interests of shareholders for an investment project. Although hedging can reduce the need for external financing, the scrutiny provided by capital markets may reduce the likelihood that proposed investment projects destroy value. Increasing internal financing by hedging can increase the expected number of value-destroying projects that would not otherwise be funded by investors outside the firm.

A corollary to the Froot et al. (1993) theory is that more financially constrained firms will hedge more. However, Rampini, Sufi, and Viswanathan (2014) claim that the empirical evidence does not support this theory and in fact shows the opposite trend; financially constrained firms will hedge less or not at all. They argue that since firms require collateral when financing investment and hedging, there is a trade-off between two. When a firm is in a low-cash state, the marginal value of internal resources is high and the firm will choose investment over engaging in risk management through hedging. Additionally, firms in such states may not have sufficient funds on hand to enter into hedging contracts and would instead put those resources into investment projects.

2.3 Empirical Literature: Commodity, Foreign Currency, and Interest Rate Hedging

One of the first studies to provide empirical evidence for these theories was performed by Tufano (1996) using gold mining firms hedging against gold prices. His analysis finds little to suggest that tax convexity or financial distress is associated with more hedging although there is more robust evidence that managers with more options (which are convex in its payoffs) tend to hedge less while those with more stock shares hedge more.

Haushalter (2000) observes gas and oil firms hedging decisions and extent of hedging. He finds that the decision to hedge or not is positively correlated with firm size. This suggests that hedging decisions are affected by economies of scale; that larger firms will hedge more often than smaller firms. The amount of hedging in which firms engage is positively related to financial leverage. Firms that have a higher debt ratio will hedge to a greater extent than less leveraged firms.

Graham and Rogers (2002) investigate more closely how tax convexity can affect firms' hedging decisions. They note that existing net operating loss carryforwards, the measure of tax convexity used by Tufano (1996) and others, provide a disincentive to hedge for firms expecting to operate at a loss but a tax incentive to hedge for firms with expected profit. They find that net operating loss carryforwards are uncorrelated with tax convexity. Instead they use a more direct measure by determining the decrease in expected tax liability from a reduction in volatility. Graham and Rogers (2002) report a statistically insignificant relationship between tax convexity and hedging but do show that hedging increases the debt ratio.

Multiple empirical analyses have been conducted to determine the effects of hedging on firm value. The first such study was done by Allayannis and Weston (2001) in which they collect data on 720 nonfinancial firms that have exposure to foreign currency risk. They find that firms that hedge against this risk exposure have firm values between 3.62% and 5.34% higher than those firms that do not.

Jin and Jorion (2006) use gas and oil firms in their analysis of the effects of hedging on firm value. They provide two major reasons why gas and oil firms are a prime industry to evaluate hedging theories. The first is that changes in gas and oil prices greatly affect cash flows in the industry. A second reason is that gas and oil firms are typically multinational in scope and are exposed to foreign currency risk which is often complex and difficult to determine. More minor reasons include more diversity in the size of firms, where as Allayannis and Weston (2001) only included large firms above $500 million, and evaluating hedging in a single industry reduces the need to account for varying average growth rates in firm value that may be present in a sample with firms in multiple industries. Finally, gas and oil firms report the characteristics of reserves (e.g., extraction costs and value of profits from reserves) separately from other firm assets. However, unlike the previous empirical work of Tufano (1996) and Allayannis and Weston (2001), who find a positive statistical relationship between hedging and firm value, Jin and Jorion (2006) find no statistical association.

Belghitar et al. (2008) also perform an analysis of UK firms that have interest rate and foreign currency risk. They argue that previous work is biased and results mixed because they only account for derivative-using firms as hedgers but include firms that hedge using other means as non-hedging firms. They propose separating firms into proper categories of derivative hedging firms, non-derivative hedging firms, and firms that choose not to hedge will allow them to determine the contribution each type of hedging firm has on value. By making these corrections, they find the coefficients for foreign currency and interest rate hedging on firm value increase by 72% and 52%, respectively. They also see that firm that hedge foreign currency or interest rates using only derivatives have greater effects on firm value than firms that use all forms of hedging.

2.4 Jet Fuel Price Hedging in the Airline Industry

In a seminal paper, Carter et al. (2006) test the relationship between hedging and firm value in the airline industry. They provide two central motivations for choosing the airline industry to study the effect of hedging on firm value. The first is that airlines are subject to significant risk exposures, particularly from increasing jet fuel prices. Second, airlines experience large distress costs and may underinvest according to Froot et al. (1993) (although this is disputed by Rampini et al. (2014)). Airlines can hedge against jet fuel price risk and possibly avoid the underinvestment problem.

Carter et al (2006) first quantify airlines' jet fuel price risk exposure which they measure in two ways. They begin by analyzing the relationship between jet fuel prices and airlines' stock price by running a time-series regression on the monthly equally weighted rate of return for the sample of airlines on the percent changes in jet fuel prices and the rate of return on the market portfolio. They find a statistically significant negative effect of changes in jet fuel prices on stock value. A one standard deviation change in jet fuel prices - 15.7 cents from 1994 to 2003 - would result in a 2.75% change in stock value. The second measure of jet fuel price risk they examine is cash flow sensitivity on a three standard deviation change in jet fuel prices. A typical airline would experience a 91% decrease in the possible value of investment if a three standard deviation rise in jet fuel prices were to occur. An airline that hedges 24% of next year's jet fuel requirements would result in 21.7% additional cash flow relative to yearly capital expenditures compared to an airline that does not hedge.

Carter et al. (2006) go on to demonstrate that the airline industry follows the Froot et al. (1993) investment framework through multiple statistical analyses. They show with a univariate analysis that jet fuel prices and cash flow are negatively correlated ($\rho = -0.487$ from 1986 to 2003) while the correlation between jet fuel prices and capital expenditures is positive ($\rho = 0.464$ from 1979 to 2003). Next, they perform a regression of capital expenditures scaled by lagged assets on inflation-adjusted jet fuel price per gallon, cash flow scaled by lagged assets, and lagged Tobin's Q. They find that the coefficient for inflation-adjusted jet fuel price per gallon to be positive and statistically significant, suggesting greater investment opportunities during periods of higher jet fuel prices. Hedging jet fuel prices would allow for airlines to better fund investment during these periods by decreasing the variability in cash flows.

Carter et al. (2006) investigate the factors that may influence an airline's decision to hedge based on the theories of Froot et al. (1993) and Smith and Stulz (1985). They consider the effects of financial constraints, tax convexity, and managerial incentives to adjust firm risk on jet fuel hedging decisions. Other factors that may affect jet fuel hedging decisions are included, such as different types of financial hedges (e.g., interest rates and foreign currencies) and other methods of reducing jet fuel price risk (e.g., fuel pass-through agreements and charter operations).

Variables from each of these categories are regressed on two measures of jet fuel hedging by airlines. The first measures the extent of jet fuel hedging, as measured by the percentage of next year's jet fuel requirements hedged. Second, airlines' decision to hedge or not to hedge, measured by an indicator which is one if the airline hedges a positive amount of next year's jet fuel requirements and zero otherwise. Carter et al. (2006) find that the factors which best explain the degree to which airlines hedge jet fuel prices match the underinvestment theory of Froot et al. (1993). However, explanatory power of the variables relevant to the underinvestment framework vanish for the model in which the indicator for jet fuel hedging decisions is used.

Next, Carter et al. (2006) explore how jet fuel hedging may affect firm value. The value of the firm is measured by Tobin's Q. The percentage of next year's fuel requirements hedged and an indicator for positive jet fuel hedging quantify the amount of jet fuel hedging and an airline's jet fuel hedging decision, respectively. They observe that an airline that hedges all of next year's jet fuel requirements has a hedging premium (i.e., an increase in firm value) of nearly 35%. For airlines that have a positive amount of jet fuel hedges in place, the average percentage of next year's fuel requirements hedged is approximately 29.4%. An airline that hedges jet fuel prices at the average has a hedging premium of 10.2%.

A potential source of the hedging premium is examined by seeing how an interaction of capital expenditures (which is a measure of investment by an airline) and jet fuel hedging affects firm value. Carter et al. (2006) find a positive and significant relationship between this interaction and firm value which shows that investment is more valuable to firms that hedge jet fuel prices than firms that do not. They find a hedging premium of almost 20.7%, nearly all of which comes from its effect on investment through capital expenditures.

In their discussion on the factors that contribute to the decision to hedge, Carter et al. (2006) note that some variables related to financial constraints (e.g., cash flow-to-sales and credit rating) show the opposite effect predicted by Froot et al. (2003). Whereas previous theory suggests more financially constrained airlines should hedge more, their analysis indicates that those airlines hedge less. Morrell and Swan (2006) argue that airlines that are in financial distress may desire to hedge but are unable since entering into hedging contracts is costly. Rampini et al. (2014), in addition to providing a theoretical basis for explaining why financially constrained firms are less likely to hedge, counter to the claims made by Froot et al. (1993), they also provide empirical support for their theory. They find that in the year before entering distress and the period of distress, the percent of fuel hedged for the following year decreases from an average of 25% to an average of 5%. They also acknowledge that airlines also understand this dynamic, as airlines consistently cite distress and the resulting collateral constrains as a reason why they do not engage in hedging.

More recent studies in the hedging literature have focused on airlines' exposure to jet fuel price risk. In a general financial sense, risk is the probability that the value of a financial item will change whereas exposure is the variance of the value the financial item due of the risk. In the current context, jet fuel price risk is the probability that jet fuel prices will change while the exposure to jet fuel prices describe how sensitive the firm value of an airline is to changes in the price of jet fuel.

Treanor et al. (2014a) provide a rational for analyzing risk and exposure from jet fuel prices by arguing that airlines inherently benefit from falling jet fuel prices. Unlike exposure due to jet fuel, foreign currency exposure depends on whether a firm is an importer or exporter on net, while interest rate exposure depends on the firm's status as a net borrower or lender. The second reason is that jet fuel costs have increased as a total share of airlines' total expenses over time. The third reason is that the price of jet fuel is far more volatile than foreign currency exchange rates and interest rates.

Treanor et al. (2014a) separate an airline's hedging activities into two major types of hedges: financial hedges and operational hedges. Financial hedges (discussed previously) involve the use of financial derivatives to protect against possible increases in the price of jet fuel. Operational hedges most commonly take the form of more fuel-efficient aircraft (by aircraft age) and fleet diversification (by aircraft size). Flying newer aircraft that are comparatively more fuel-efficient than older aircraft reduces the amount of fuel needed to fly the same number of routes, which then reduces the negative impact on the airline's profit when fuel prices are high. Similarly, when an airline maintains a diverse fleet with different sizes of aircraft (with each having differing fuel capacities), the airline can switch to smaller aircraft when fuel prices are high to reduce overall fuel expense. Although the airline may sacrifice economies of scale associated with larger aircraft, it may be more costly to continue to operate large aircraft or leave the market completely and reenter at a later time than to operate smaller aircraft at a loss. Operational hedges can still benefit airlines even when jet fuel prices are low, while financial hedges generally cannot. However, operational hedging can be more costly than financial hedges because of the high capital cost of acquiring additional aircraft and the considerable maintenance costs of maintaining a diverse fleet. When comparing the reduction in exposure to financial and operational hedging, Treanor et al. (2014a) find that a one percent increase in the amount of fuel hedged in the next year reduces jet fuel price exposure by 1%. Alternatively, a one-year reduction in fleet age or a 1% increase in fleet fuel efficiency can reduce fuel risk exposure by 2.3% and 11%, respectively.

Treanor, et. al. (2014b) expand on the work of Carter, et. al. (2006) by including jet fuel exposure in airlines' hedging decisions and how changes in hedging behavior due to jet fuel exposure affects firm value. They first find that airlines that are subject to greater jet fuel exposure hedge more. Airlines that have an 8.5% increase in jet fuel exposure hedge on average 10.7% more of next year's expected jet fuel requirements. However, the increase in hedging when jet fuel exposure is high has no association with an increase in the firm value of airlines. They suggest that airlines simply value hedging jet fuel prices generally and not necessarily selective hedging during times of high jet fuel exposure.

2.5 Overview of Commodity Price Hedging

Carter et al. (2017) attempt to aggregate the general findings of the commodity risk management literature and provide possible directions for future research. Beginning with the Modigliani and Miller theorem in which hedging cannot increase the value of the firm in perfect and efficient markets, numerous authors have shown that in the absence of this perfect world, investors can value hedging through a multitude of avenues. Changes in accounting standards have led to an improvement in data availability which allows investigators to more easily analyze questions involving hedging decisions and their impact on the firm. They note that empirical findings regarding hedging decisions may depend on the industry being analyzed or whether the firms examined are producers or users of the commodity, as well as differences in economic conditions of the time periods studied.

Carter et al. (2017) suggest multiple questions that future research can consider. In particular are concerns about differences in results between industries and replication of results within industries over different time periods. Studies on corporate culture may be necessary and mergers between firms or changes in management can change hedging decisions and strategies. Finally, they suggest that research should be able to help businesses with the decision to hedge or not, and if so how much. Field-based case studies may provide valuable insight into how firms actually make hedging decisions.

CHAPTER 3:

DATA SOURCES AND COLLECTION

3.1 Database Overview

The data for the analyses performed in this dissertation come from three sources. General financial data are found in the Compustat database. This database is maintained by Wharton Research Data Services (WRDS) within the Wharton School of the University of Pennsylvania. Data for risk management strategies used by airlines are manually recorded from Securities and Exchange Commission (SEC) 10-K statements.[3] These filings are publicly available on the Electronic Data Gathering, Analysis, and Retrieval system (EDGAR) maintained by the SEC. Airline passenger data and ticket fare data are taken from Air Carrier Statistics (T-100) database and the Airline Origin and Destination (DB1B) survey, respectively. The Office of Airline Information of the Bureau of Transportation Statistics (BTS) manages both databases. Each of the two databases can be found on the Transtats website, also maintained by the BTS.[4]

Each section of this chapter provides a detailed discussion of the data collection methods and calculations for the variables obtained from each database. Section 3.2 describes the variable names and locations of financial data within Compustat and the different company codes that can be used to identify airlines within the database. Section 3.3 shows how to collect

[3] The SEC describes Form 10-K as a document that provides a comprehensive overview of a company's business and financial condition and includes audited financial statements.
[4] https://www.transtats.bts.gov/

jet fuel hedging data within airline 10-K statements. This includes information on the amount of hedging airlines engage in and the gains and losses airlines receive from those hedges. Examples of jet fuel hedging reporting by airlines in selected 10-K statements are given. Data for other risk management strategies, such as interest rate hedges and fuel pass-through agreements, are also covered. Section 3.4 demonstrates how passenger and ticket fare data for each airline are aggregated across different markets and time intervals (e.g., total passengers flown yearly, quarterly, etc. for an origin/destination pair).

3.2 Compustat Database

Most financial variables are found in Compustat under North America – Annual Updates – Fundamentals Annual. These items are separated in multiple categories: balance sheet items, income statement items, cash flow items, miscellaneous items, and supplemental data items. Table 3.1 shows the variable name, the category the variable can be found in the Compustat Fundamentals Annual database, and the item name. Credit rating variables can be found in Compustat under North America – Annual Updates – Ratings in the "Data Items" category. S&P Long Term Issuer Credit Rating is selected as the credit rating variable used in the analyses.

Executive compensation variables are located in Compustat under Execucomp – Monthly Updates – Annual Compensation. Total shares owned excluding options and the number of options awarded are taken from the "Compensation Data" category. The Annual CEO Flag in the "Executive Information" category indicates which executive was the CEO of the company for most of the fiscal year.

Companies can be identified through six different types of company codes: ticker symbol, GVKEY, CUSIP, SIC, NAICS, and CIK. The primary company identifier used is

GVKEY. Compustat permanently associates GVKEY with a single company over its entire life, whereas the other company codes may be changed and reused over time. Each of these company identifiers can be selected in any data query report under the "Identifying Information" grouping.

3.3 EDGAR Database

Financial hedging data are not directly available in any Compustat database. However, information regarding a company's financial hedging activities are reported in their annual 10-K filings with the SEC. These filings are publicly accessible from the EDGAR database. Documents available in EDGAR go back to 1994 filings. Airlines are identified in EDGAR with their stock ticker symbols.

For any year in which a 10-K is not available, the company may have submitted a 10-K405 filing. This form is identical to a 10-K form and is required to be filed if a director or other officer of a company failed to submit Form 3, Form 4, or Form 5 on time to disclose any insider trading activities. 10-K405 filings were discontinued after 2002.

3.3.1 Jet Fuel Hedging Measures from Form 10-K

An airline's jet fuel hedging activities are measured in two ways: (1) by the percentage of an airline's expected jet fuel requirements for the next year hedged, and (2) the gains or losses from an airline's jet fuel hedges. The percentage of next year's jet fuel requirements hedged measures the *amount* of jet fuel hedging each airline engages in relative to its expected fuel requirements for the following year, while the gains or losses from an airline's jet fuel hedges measure the *performance* of its jet fuel hedging activities.

3.3.1.1 Percentage of Next Year's Jet Fuel Requirements Hedged

Airlines report the percentage of next year's expected jet fuel requirements hedged in multiple ways. Most airlines report the amount of jet fuel hedging as a yearly value. Southwest Airlines (2004), for example, reported that it will hedge over 82 percent of fuel requirements for 2004. The expected amount of fuel requirements hedged may also be given quarterly. Alaska Airlines (2008), for example, reported hedges in place for approximately 50% of fuel requirements in the first quarter of 2008, 38% in the second quarter, 33% in the third quarter, and 34% in the fourth quarter (see Figure 3.1). Alaska also gives the full year expected fuel requirements hedged at 39%. This is the arithmetic average for each of the four quarters (rounded to the nearest whole percent). When quarterly hedging values are given without a full year hedging value, the yearly value is calculated as the arithmetic average of the percentage of jet fuel hedging for each of the four quarters. Airlines may also report the expected number of gallons hedged. The corresponding percentage of expected fuel requirements hedged is calculated by dividing expected gallons hedged with total expected fuel requirements for the following year. For example, Delta Air Lines (1999) disclosed that it expected to hedge 2.1 billion gallons of jet fuel in 1999 and projected its fuel consumption for 1999 to be 2.7 billion gallons. This computes to a percentage of next year's expected jet fuel hedged of 76.9%.

Airlines may disclose jet fuel hedging activities not only for the next year, but also two or three years into the future. These hedging activities beyond one year in the future are not included in the data. Airlines may alter their hedging contracts for future years beyond the first. In 2007, for example, Alaska Airlines had hedging contracts in place for 39% of its expected jet fuel requirements for 2008 and 5% of its expected jet fuel requirements for 2009 (Alaska Air

Group, 2008).[5] By 2008, it purchased additional hedging contracts for a total of 50% of its 2009 fuel requirements (Alaska Air Group, 2009).

It is important to note that not all practices that manage jet fuel price risk for an airline are counted as hedges. Smaller airlines sometimes use fuel pass-through agreements to pass on the cost of using jet fuel to a party other than the airline.[6] These agreements do not alter the jet fuel price risk borne by the airline, but simply pass on that risk to the other airline in the agreement. For any year in which an airline does not have any financial derivatives in place to hedge jet fuel price risk for the following year, its expected fuel requirements hedged for next year will be zero, even if the airline passes on some or all of its jet fuel price risk to another airline by using some type of fuel pass-through agreement. These types of non-hedging jet fuel risk management activities are discussed in section 3.3.2.

3.3.1.2 Gains and Losses from Jet Fuel Hedges

Prior to 2001, the reporting gains and losses from jet fuel hedges in 10-K statements was optional and reporting practices were inconsistent between airlines. In June of 1998, the Financial Accounting Standards Board passed FAS 133, Accounting for Derivatives Instruments and Hedging Activities, which required companies to report the fair value of their derivative instruments on their balance sheet.[7] All companies were required to adopt FAS 133 by January 1, 2001. If an airline engages in jet fuel hedging by using financial derivatives, it must report the

[5] Figure 3.1 shows an example of how Alaska Airlines reports the expected fuel requirements hedged for multiple years.
[6] Types of fuel pass-through agreements include fixed-price and cap arrangements, fuel purchase agreements, airline service agreements, code share agreements, capacity purchase agreements, and contract flying arrangements.
[7] The fair value of a financial derivative is the value of the instrument if it were settled at a given time. This is often referred to as the mark-to-market value of the instrument.

fair value of those derivatives as assets or liabilities on its balance sheet. FAS 133 guarantees that data on gains and losses from jet fuel hedging is reliable and consistent between airlines.

Gains and losses from hedging are divided into four categories: realized gains and losses, unrealized gains and losses, gains and losses from ineffective hedges, and gains and losses from hedges that do not qualify for hedge accounting. Airlines report realized gains when a financial derivative has been exercised and the underlying fuel has been consumed. These gains are generally reported under fuel expense or are reclassified from accumulated other comprehensive income (AOCI) into income as fuel expense. Unrealized gains and losses are changes in the mark-to-market value of all financial derivatives that have not been exercised. Unrealized gains and losses are commonly recognized under AOCI. Gains and losses from ineffective hedges are declared as ineffective and documented as nonoperating income. For any hedges that do not qualify for hedge accounting, gains and losses are also reported as nonoperating income. All gains and losses are after-tax values.

Figure 3.2 shows an example of gains and losses classifications from United Airlines' jet fuel hedging activities in its 2014 10-K filing. United Airlines' unrealized gains fall under "Amount of Gain (Loss) Recognized in AOCI on Derivatives (Effective Potion)" which amounts to a gain of $39 million in 2013 but a loss of $51 million in 2012.[8] The airlines' realized gains and losses are classified under "Gain (Loss) Reclassified from AOCI into Income (Fuel Expense) (Effective Potion)." 2013 shows a realized gain of $18 million and a $141 million realized loss in 2012. The ineffective potion of jet fuel hedges is labeled as "Amount of Gain (Loss) Recognized in Nonoperating income (expense): Miscellaneous, net (Ineffective Portion)."

[8] Although losses are indicated as being enclosed in parentheses in this example, this is not always a consistent reporting standard. Airlines can report gains in parentheses as well, so care must be taken when interpreting hedging gains and losses.

Ineffective gains and losses were positive $5 million in 2013 but losses of $1 million in 2012. Hedges that do not qualify for hedge accounting amount to a gain of $79 million and $38 million in 2013 and 2012, respectively. These gains and losses fall under "Amount of Gain Recognized in Nonoperating income (expense): Miscellaneous, net."

3.3.2 Other Variables Taken from Form 10-K

Airline 10-K statements contain information on other types of risk management activities, including interest rate hedges, foreign currency hedges, usage of fuel pass-through agreements, and charter arrangements with other companies. Data for each of these types of risk management are collected as indictors variables. Interest rate and foreign currency hedge indicators are assigned a value of one if the airline uses interest rate or foreign currency hedges at any time during the year and zero otherwise.[9] The fuel pass-through agreement indicator and charter indicator are given a value of one if an airline passes on its fuel costs to another airline or maintains charter operations with at least one other airline, respectively, and zero otherwise.

3.4 Bureau of Transportation Statistics Databases

Airline passenger and ticket fare data are taken from databases managed by the Office of Airline Information of the BTS. Passenger data are retrieved from the Air Carrier Statistics database, also called the T-100 data bank, while ticket fare data are collected from the Airline Origin and Destination Survey, commonly referred to as the DB1B survey.

[9] The most common interest rate hedges used are swaps and interest rate caps, while swaptions and treasury lock agreements are less commonly used. Foreign currency hedges include call and put options, collars, futures, and swaps.

3.4.1 T-100 Data Bank

The T-100 data bank contains four distinct tables: T-100 domestic segment, T-100 domestic market, T-100 international segment, and T-100 international market. The BTS defines a segment as a pair of points served or scheduled to be served by a single stage of at least one flight at any given time. Market data include passengers, freight, and/or mail that enplane and deplane between two specific points while the flight number remains the same. Data in domestic tables are comprised of all flights where both the origin and destination airports are within the boundaries of the United States or its territories. International tables include flights where at least one of the points of service is within the United States or its territories. This study only uses passenger data from the domestic market table.

Passenger data are gathered monthly for each pair of origin and destination markets from each reporting airline.[10] Airlines are required to report passenger numbers for all flights. The airline ID variable in the database is used to identify unique airlines. This five-digit identifier is constant for each holder of a Certificate of Public Convenience and does not change over time. In contrast, airline names, codes (e.g., AA for American Airlines), and holding companies/corporations may change due to bankruptcies or mergers with other airlines. Markets are identified by a five-digit market ID. Some markets, however, are served by multiple airports. When an airline flies passengers at multiple airports within the same market, passenger data are reported for each airport.

Passenger data are aggregated in two ways: by city-pair market and by year. The Federal Aviation Administration defines a city pair as a city of origin and a corresponding destination

[10] Reporting airlines must hold a Certificate of Public Convenience and Necessity issued by the U.S. Department of Transportation and have at least $20 million in annual operating revenues.

city for flights to and from major metropolitan areas ("City Pairs," 2018). In the dataset, flights to and from two unique markets as defined by the T-100 market ID are defined as a city-pair market. To assist in passenger data aggregation across city-pair markets, a new six-digit city-pair market identifier is constructed so that it is independent of which market is the origin and which market is the destination. First, a new three-digit market identifier is generated for each market so that it is the same whether the market is an origin or destination. The city-pair market identifier is created by using the maximum new market ID of the origin/destination pair as the first three digits and the minimum new market ID of the same origin/destination pair as the second three digits.[11] This eliminates the possibility that two unique city-pair markets can have the same city-pair market identifier.

Passengers are also aggregated within each city-pair market by year for each airline. The yearly passengers flown by each airline in a city-pair market is calculated by summing the number of passengers flown by an airline for each month of a given year across all observations with the same city-pair market identifier. Any year and city-pair market in which an airline did not fly any passengers is assigned a value of zero for that airline year.

The yearly passenger share for each airline in a city-pair market is calculated by taking the ratio of the number of passengers flown by the airline and the total number of passengers flown by all airlines in that city-pair market. Any airline that has flown zero passengers in a city-pair market year is given a passenger share of zero. Passenger shares are expressed as a percentage of total passengers with values ranging from 0 and 100.

[11] For example, the Tampa, Florida market has a new market ID of 222 and Phoenix, Arizona has a new market ID of 39. The city-pair market identifier for these two markets is 39222.

3.4.2 DB1B Survey

In contrast to the T-100 data bank which requires reporting airlines to submit detailed passenger data for all flights every month, the DB1B surveys 10% of tickets from reporting airlines every quarter. The DB1B survey is divided into three tables: DB1BCoupon, DB1BMarket, and DB1BTicket. The DB1BMarket table supplies information regarding origin and destination market IDs that the other two tables do not have. Since the market IDs in the DB1BMarket are identical to the market IDs of the T-100 data bank, this allows for consolidation of the fare data with the T-100 passenger data for any city-pair market.

Airlines in the DB1BMarket are not directly identified by the airline ID as in the T-100 data bank. Instead, three separate identifiers are employed: the reporting carrier, the operating carrier, and the ticketing carrier. The reporting carrier is the airline that submits data to the Office of Airline Information for any given passenger segment. The operating carrier is the airline directly involved in the operation of the aircraft. The marketing carrier is the airline that issues a flight reservation or ticket under a codeshare agreement.[12] Since the operating carrier submits data for the T-100 data bank, the operating carrier in the DB1BMarket table is used as the airline identifier (Lundy, 2016). Since the operating carrier is identified using the International Air Transport Association (IATA) airline designator (e.g., AA for American Airlines) instead of the airline ID identifier in the T-100, the IATA airline designator is converted to the corresponding airline ID identifier.

The price of a flight is usually given by the ticket fare for the flight. Using this measure of price may introduce bias as longer flights will generally have higher fares. This bias can be

[12] A code share agreement is an arrangement in which one airline puts its IATA two-letter code on a flight operated by a different airline ("Code Share Fact Sheet").

corrected by using the ticket fare per mile flown as the price of a flight.[13] The DB1B survey presents this measure of ticket price as the total itinerary yield, which is defined as the itinerary fare (i.e., the ticket fare) divided by the itinerary miles flown (e.g., the number of miles flown between the origin and destination). In the DB1BMarket table, however, the itinerary yield is not given directly. Instead, the itinerary fare (market fare) and the itinerary miles flown (market miles flown) are provided. This allows the itinerary yield for each ticket to be computed by taking the ratio of the market fare and the market miles flown. The average itinerary yield is used as the average price of a ticket for each airline in a city-pair market. The average itinerary yield is calculated as the weighted average of the itinerary yields for each origin/destination combination within a city-pair market.[14]

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[13] This does not account for other factors that can introduce sampling bias, including seasonal fare differences and fare class differences (e.g., first class, business class, economy, etc.).

[14] A weighted average is used because the number of tickets surveyed for each origin/destination pair may be different. If the number of tickets surveyed for flights from Tampa, Florida to Phoenix, Arizona is 100, and the number of tickets surveyed on flights from Phoenix to Tampa is 150, then the weight on the two average itinerary yields will be 0.4 (100/250) and 0.6 (150/250), respectively.

Table 3.1: Names and Locations of Variables within Compustat

Base Variable	Compustat Name	Item Category
Assets	AT -- Assets - Total	Balance Sheet
Share Price	PRCC_F -- Price Close - Annual - Fiscal	Supplemental Data
Capital Expenditures	CAPX -- Capital Expenditures	Cash Flow
Cash	CH -- Cash	Balance Sheet
Common Stock Shares Outstanding	CSHO -- Common Shares Outstanding	Miscellaneous
Depreciation	DP -- Depreciation and Amortization	Income Statement
Long-term Debt	DLTT -- Long-term Debt - Total	Balance Sheet
Net Income	NI -- Net Income (Loss)	Income Statement
Preferred Stock Liquidating Value	PSTKL – Preferred Stock Liquidating Value	Balance Sheet
Sales	SALE -- Sales/Turnover (Net)	Income Statement
Short-term Assets	ACT -- Current Assets - Total	Balance Sheet
Short-term Liabilities	DLC -- Debt in Current Liabilities – Total	Balance Sheet
Tax loss Carryforward	TLCF -- Tax Loss Carry Forward	Balance Sheet
Dividends	DVT -- Dividends – Total	Income Statement
Advertising	XAD -- Advertising Expense	Income Statement
Working Capital	WCAP -- Working Capital (Balance Sheet)	Balance Sheet
Retained Earnings	RE -- Retained Earnings	Balance Sheet
Earnings Before Interest and Taxes	EBIT – Earnings Before Interest and Taxes	Income Statement
Market Value of Equity	CEQ -- Common/Ordinary Equity – Total	Balance Sheet
Total Liabilities	LT -- Liabilities – Total	Balance Sheet
Inventories	INVT -- Inventories -Total	Balance Sheet

Notes: This table shows the location of each variable taken from Compustat under North America – Annual Updates – Fundamentals Annual. The first column shows the variable name, the second column provides the variable name as it is found in Compustat, and the third column gives the category where the variable can be found.

Outstanding fuel hedge positions as of December 31, 2007 are as follows:

	Approximate % of Expected Fuel Requirements	Gallons Hedged (in millions)	Approximate Crude Oil Price per Barrel
First Quarter 2008	50%	49.7	$ 66.88
Second Quarter 2008	38%	39.7	$ 66.71
Third Quarter 2008	33%	37.7	$ 68.62
Fourth Quarter 2008	34%	35.3	$ 68.21
Full Year 2008	**39%**	**162.4**	**$ 67.53**
First Quarter 2009	5%	5.6	$ 67.68
Second Quarter 2009	5%	5.8	$ 67.50
Third Quarter 2009	6%	6.3	$ 68.25
Fourth Quarter 2009	5%	5.3	$ 67.20
Full Year 2009	**5%**	**23.0**	**$ 67.68**

Figure 3.1: Alaska Airlines Expected Jet Fuel Requirements Hedged from 2008 10-K Statement

Notes: This figure shows the percentage of Alaska Airlines' expected fuel requirements hedged quarterly and yearly in 2008 and 2009 from its 2007 10-K filing. The expected yearly amount of jet fuel hedged in each year is the arithmetic average of the quarterly percentages rounded to the nearest percent. The number of gallons hedged and the price per barrel of crude oil is shown but not collected for this dataset. Source: Alaska Air Group (2008).

The following tables present the fuel hedge gains (losses) recognized during the periods presented and their classification in the financial statements (in millions):

Derivatives designated as cash flow hedges

	Amount of Gain (Loss) Recognized in AOCI on Derivatives (Effective Portion)		Gain (Loss) Reclassified from AOCI into Income (Fuel Expense) (Effective Portion)		Amount of Gain (Loss) Recognized in Nonoperating income (expense): Miscellaneous, net (Ineffective Portion)	
	2013	2012	2013	2012	2013	2012
Fuel contracts	$ 39	$ (51)	$ 18	$ (141)	$ 5	$ (1)

Derivatives not designated for hedge accounting

	Amount of Gain Recognized in Nonoperating income (expense): Miscellaneous, net		
	2013	2012	2011
Fuel contracts	$ 79	$ 38	$ —

Figure 3.2: United Airlines Jet Fuel Hedging Gains and Losses from 2014 10-K Statement

Notes: This table displays the results of United Airlines' hedging activities for 2012 and 2013. Unrealized gains and losses are recognized in AOCI, realized gains are reclassified from AOCI into income, ineffective gains and losses are recognized in nonoperating income as ineffective, and hedges that do not qualify for hedge accounting are recognized in nonoperating income. Source: United Continental Holdings (2014).

CHAPTER FOUR:

HEDGING GAINS AND LOSSES AND FIRM VALUE

4.1 Background

4.1.1 Justification for Replication

One of the suggestions from Carter et al. (2017) on the future of hedging research is the reproduction of previous work over different time periods and samples of firms within the same industry. A prime candidate for replication is the seminal empirical study on jet fuel price hedging in the airline industry done by Carter, Rogers, and Simkins in 2006 They find a jet fuel "hedging premium" – an increase in firm value from hedging - of approximately 10.2%. Additionally, they show that the source of the increased value comes from additional capital expenditures due to jet fuel hedging. This comports with the theory of Froot, Scharfstein, and Stein (1993), that hedging allows firms to finance additional investment that they would not be able to fund otherwise. There are numerous reasons why another analysis of the hedging premium will improve understanding of hedging by airlines.

The first reason for performing a more recent analysis is that hedging has been a part of the risk management landscape in the airline industry for a longer period of time. This allows an investigation into hedging behavior and the hedging premium over different periods of time. Carter Rogers and Simkins (2006) use a sample of twenty-eight unique airlines over a period from 1992 to 2003 (this chapter will henceforth refer to the data used by Carter, Rogers, and

Simkins (2006) and the 1992 to 2003 time period in their study as the "CRS data" and "CRS time period," respectively). During this time, there were no major events that greatly affected the price of jet fuel, and the only important event that affected the airline industry (the September 11, 2001 terrorist attacks) occurred towards the end of the period.

Since 2003, the price of jet fuel has become significantly more volatile. Over the course of the CRS time frame, the price of jet fuel varied from 0.3 to 1.05 dollars per gallon with a standard deviation just over 0.15 dollars per gallon. The largest month-to-month increase in jet fuel prices was 0.50 dollars per gallon. In the 11 years after, from 2004 to 2014, the high jet fuel price nearly quadrupled to 3.88 dollars per gallon while never falling below 0.93 dollars per gallon. The standard deviation of jet fuel prices increased almost by a factor of five to 0.70 dollars per gallon, with a high month-to-month increase of 1.00 dollars per gallons. The advantage that hedging airlines have over non-hedging airlines may be greater during periods when changes in jet fuel prices are significantly larger in magnitude than when changes are more modest.

A second reason for revisiting jet fuel hedging is that airlines are choosing to hedge more often. In the CRS time period, airlines hedged on average 10.9% of their future jet fuel requirements (see Carter, Rogers, and Simkins (2006), Table IV on p. 67).[15] Airlines hedged a positive amount of their future jet fuel requirements in 37% of all airline-year observations (p. 67). Between 1995 and 2014 (the time period used in the analysis performed in this dissertation), the average percentage of jet fuel hedged for all years rose to 14.8%, and 51.4% of all airline-years had a positive amount of jet fuel hedging. However, the average amount of jet

[15] The 10.9% figure includes airline-years in which the amount of jet fuel hedging is zero.

fuel hedged in airline-years with a positive amount of hedging has remained relatively constant; 29.4% from 1992 to 2003 (see Carter, Rogers, and Simkins (2006), Footnote 5, p. 59) and 28.8% from 1995 to 2014. One possible explanation for the increase in hedging is that airlines have an incentive to hedge jet fuel more often as its price becomes more volatile. Not hedging jet fuel prices, especially when the magnitude of an unexpected increase in price is greater than before, will be more costly. As airlines gain experience with hedging and have a greater understanding of its ability to add value, they will hedge more whenever possible.

A final reason for a new study of jet fuel hedging concerns is the discrepancies in the theoretical hedging literature on whether financially constrained firms are likely to hedge more or less. Further empirical study is necessary to determine the correct theory. Froot, Scharfstein, and Stein (1993) argue that firms more likely to enter financial distress may hedge to reduce the probability of becoming distress or filing for bankruptcy. On the other hand, Rampini, Sufi, and Viswanathan (2014) contend the opposite, that financially constrained firms will hedge less because they do not have the collateral available to purchase hedging contracts. Carter, Rogers, and Simkins (2006) provide evidence for the latter theory that financial constraint variables have negative associations with the amount of hedging airlines engage in (although they note the seeming contradiction between the Froot, Scharfstein, and Stein (1993) framework and their result).

4.1.2 Study Extension: Hedging Gains and Losses

In the jet fuel hedging literature, hedging has been quantified by the amount of hedging engaged in by the airline. This is typically measured by the percentage of next year's expected fuel requirements that an airline expects to hedge with financial derivatives. The more of its overall jet fuel requirements an airline hedges, the greater the reduction in price risk on its jet fuel purchases.

However, because jet fuel hedges are costly, the hedge will only provide value if the spot price of the jet fuel falls within a range where the hedging contract gains value. If an airline has a call option for a barrel of oil with a strike price of $100 and a premium paid to the seller of the call option of $10, then the call option will only have a positive value for the airline if the spot price of jet fuel plus the premium is above $110. Otherwise, the airline will lose value from the hedge if the spot price of jet fuel remains below that amount. The implicit assumption that is required to explain how jet fuel hedging provides value to airlines is that the expected value of its jet fuel hedges is at least zero.

The jet fuel hedging literature does not explicitly take into account the success or failure of jet fuel hedges in its effect on firm value. A possible reason for this oversight is that gains and losses data for a firm's hedging contracts are unreliable before 2001. In June 1998, the Federal Accounting Standards Board (FASB) issued Statements of Financial Accounting Standards No. 133, Accounting for Derivatives Instruments and Hedging Activities (FAS 133) which required firms to report the fair value of hedging contracts on their balance sheet. Although firms were initially required to adopt FAS 133 in the years beginning after June 15, 1999, FASB soon passed FAS 137 which delayed the implementation of FAS 133 by one year (Southwest, 2001). Although some airlines did begin reporting on their hedging activities earlier than required, most airlines did not fully adopt FAS 133 until January 2001.

There are two important types of gains and losses reported on jet fuel hedges that may influence firm value. Unrealized gains and losses from jet fuel hedges are the changes in the fair value of the hedges when the spot price of jet fuel changes. These gains and losses do not result in any changes to the cash flow in the airline. They only represent a mark-to-market change in the value of an unexercised financial derivative. Since unrealized gains and losses describe the value of an asset, changes in the value of the asset should have a positive relationship with firm value.

The second significant type of gain and loss from hedging is realized gains and losses. These gains and losses are a result of exercising a hedging contract to purchase jet fuel. Unlike their unrealized counterparts, realized gains and losses will affect the airline's cash flow. If an airline realizes positive gains on its hedges, then it may be able to use the increased cash flow to fund investment. Realized gains and losses should have a positive relationship with firm value.

4.2 Jet Fuel Price Exposure

One of the most significant risk exposures that airlines face comes from the volatility of jet fuel prices. Carter, Rogers, and Simkins (2006) first measure risk exposure from jet fuel prices by regressing the monthly equally-weighted rate of return for the sample of airlines on the return for an equally-weighted market portfolio and the percent change of the Gulf Coast jet fuel spot price. They find a 1% increase in jet fuel prices would correspond to a 0.11% decrease in airline stock prices. For a one standard deviation increase in the price of jet fuel – a 25% change – the airline industry's average monthly stock price would decrease by nearly 2.75% (p. 60).

This analysis is repeated for the current sample of airlines from January 2000 to December 2014.[16] Over this time period, the coefficient on the percent change in jet fuel price was -0.35, that is, a 1% increase in jet fuel prices would correspond to a 0.35% decrease in

[16] The earliest date available for the rate of return variables in the Center for Research in Security Prices (CRSP) database is January 2000. The airlines chosen for this study come directly from the sample selected by Rampini, Sufi, and Viswanathan (2014).

airline industry stock prices. For a one standard deviation increase in the price of jet fuel – a 48% change in this sample – the average monthly stock price for airlines would decrease by 16.8%. This effect of a one standard deviation change in jet fuel prices is significantly larger in this study than the result in Carter, Rogers, and Simkins (2006). This is driven by both the increased sensitivity to airline stock prices and the higher variance in jet fuel prices over the time frame of this analysis.

4.3 Summary Statistics and Variable Discussion

The summary statistics for the variables used in the reproduction of the Carter, Rogers, and Simkins (2006) study are provided in Table 4.1. The date range for these variables is 1995 to 2014. Column (6) of the table gives the mean values for the variables from the original analysis with a date range of 1992 to 2003.

Jet fuel hedging is measured by two variables, the fraction of next year's jet fuel requirement hedged and an indicator for a positive fraction of jet fuel hedged. The fraction of next year's jet fuel requirements hedged is a continuous variable that describes the amount of jet fuel hedging that an airline engages in. The jet fuel hedging indicator is a binary variable that is one if the airline hedges a positive amount of its expected jet fuel requirements for the following year and zero if the does not hedge any of its jet fuel requirements next year. This variable only considers the airlines decision to hedge some positive fraction of its future jet fuel requirements. Compared to the CRS data, airlines are hedging their future jet fuel requirements more often and hedging a greater amount of their expected jet fuel usage than before.

Firm value is measured by Tobin's Q. Carter, Rogers, and Simkins (2006) use an approximation of Tobin's Q described by Chung and Pruitt (1994). For the data used in this dissertation, the minimum value of the Q ratio is -0.240. Since Tobin's Q cannot be negative, a potential remedy for this problem is to translate all values of Tobin's Q by adding constant, α, to eliminate any negative values before performing a log transformation. The value of α is chosen so that the new minimum value is close to the minimum Tobin's Q from the CRS data. In this dissertation, a value of $\alpha = 0.280$ is chosen. The statistics for Tobin's Q after the adjustment are shown in Table 4.1.

Firm size, debt capacity, and intensity of investment are provided by the log of total assets, long-term debt-to-assets, and capital expenditures-to-sales, respectively. Airlines are larger in size than before, most likely as a result of consolidation of airlines within the industry due to significant mergers between major carriers. Airlines have greater leverage compared to the CRS data. The amount of investment by airlines is nearly identical in both studies.

Carter, Rogers, and Simkins (2006) adjust the log of assets, Tobin's Q, capital expenditures-to-sales, and long-term debt-to-assets to account for operating leases of aircraft that do not appear on an airline's balance sheet. Damodaran (2002) provides a method for this adjustment by adding the net present value of operating leases to total assets and long-term debt. Changes in the previous two variables result in a lease-adjusted Tobin's Q (which remains translated as described above). Capital expenditures are adjusted by adding the net present value of operating leases to capital expenditures. After accounting for operating leases, airlines are still larger and have more leverage on average in this study's data, although the average level of investment declined.

Financial constraint variables include cash flow-to-sales, cash-to-sales, credit rating, and Z-score.[17] Cash flow-to-sales and cash-to-sales are measures of internal financing for investment and collateral available to purchase hedging contracts. Although cash flow-to-sales are similar in the CRS data and the data for this study, airlines have lower cash-to-sales on average in this study. Credit rating and Z-score provide proxies for the probability of bankruptcy while credit rating may also be considered as a measure of an airline's ability to secure external financing.[18] The average end of year credit rating is slightly higher (e.g., a lower numerical value) compared to the CRS data. However, airlines in this study have a greater probability of bankruptcy based on lower average Z-scores compared to the CRS data.

Tax loss carryforwards-to-assets are a proxy for tax convexity. Airlines that take advantage of tax loss carryforwards reduce the tax liability for time periods when profits are positive. This suggests that use of tax loss carryforwards is positively related to the convexity of a firm's tax function. This dissertation's sample of airlines displays a higher use of tax loss carryforwards than in the CRS study.

Managerial compensations variables consider the number stock and stock option awards in all executives and CEO compensation packages as a fraction of total shares outstanding for the airline. Between this study's data and the CRS sample, executives and CEOs are both receiving stock and option awards that are a smaller fraction of outstanding shares. This is likely a result

[17] Credit ratings are given as numerical values with 2 being the highest credit rating (AAA) and 28 the lowest (D). Airlines without credit ratings in a given year are given values of 30 to be consistent with Carter, Rogers, and Simkins (2006).
[18] Carter, Rogers, and Simkins (2006) do not explicitly state a yearly measure of credit rating (e.g., mean, median, or end of year credit ratings). Regressions in this study use end of year credit ratings, although there are no significant changes in results using any of the yearly constructions for credit rating.

of stock and option compensation increases being outpaced by the growth of the airline's outstanding stock shares.

The last set of variables account for other forms risk management. Fuel pass-through agreements and charters operations are two additional ways that an airline can reduce its jet fuel price risk by passing it on to another airline. Airlines use financial derivatives to hedge against interest rate and foreign currency risk. Each of these forms of risk management is represented by a binary variable. The fuel pass-through indicator equals one if the airline has an agreement in place that transfers the fuel costs to another airline and zero otherwise. The charter indicator is one if the airline charters some portion of its aircraft to another airline or individual customers and zero otherwise. In the time period for this analysis, the fraction of airline-years in the sample where there are fuel pass-through agreements or charter operations have both declined. The interest rate and foreign currency indicators are one if the airline holds any kind of financial derivate to hedge against changes in interest rates or foreign currencies, respectively, and zero otherwise. Airlines are hedging against interest rates slightly less often in this study but hold derivative instruments for foreign currencies more often compared to the CRS data.

4.4 Determinants of Jet Fuel Hedging

The first major empirical analysis done by Carter, Rogers, and Simkins (2006) is to evaluate the firm characteristics that influence hedging by airlines. They create a model based on the theoretical work of Smith and Stulz (1985) and Froot, Scharfstein, and Stein (1993). The most important factors from these theories that affect airlines' hedging decisions include financial constraints, tax convexity, and managerial incentives. Although they are not explicitly discussed in the general hedging theories, other factors that can affect airlines' hedging practices are used as controls in the model. Airlines may employ other methods of managing jet fuel price risk, such as charter operations and fuel pass through agreements, and hedge risk from sources like interest rates and foreign currencies.

The base model used to determine the effects that these variables have on jet fuel hedging is described by equation (1) below.

$$J_{it} = \alpha_0 + \beta F_{it} + \gamma X_{it} + \delta M_{it} + \theta G_{it} + u \quad (1)$$

J is the measure of jet fuel hedging by airline *i* at time *t*. F represents financial constraint variables described above. *X* represents tax convexity measured by tax-loss carryforwards. *M* represents managerial incentive variables, and *G* represents other forms of risk management. *u* is the idiosyncratic standard error.

4.4.1 Predicted Effects on Jet Fuel Hedging

In Table 4.2, column (1) shows the expected effects that each of the controls should have on hedging by airlines as predicted by Rogers, Carter, and Simkins (2006).[19] Each of the explanatory variables in the table is separated into one of four different groups: (A) financial constraint variables, (B) tax convexity, (C) managerial incentives, and (D) other risk management strategies. Cells with a plus sign (+) indicate a positive relationship with hedging where higher values of the explanatory variables correspond to more hedging. Similarly, cells with a minus sign (-) indicate a negative association with hedging. Higher values correlate to less hedging.

Columns (2) to (4) of Table 4.2 provide the signs of the results in Table V from Carter, Rogers, and Simkins (2006, p. 69). Columns (2) and (3) both use the continuous jet fuel hedging measure as the dependent variable, and column (3) replaces Tobin's Q, log of assets, capital

[19] See pages 66-70 of Carter, Rogers, and Simkins (2006) for a discussion of each variable's effect on hedging.

expenditures-to-sales, and long-term debt-to-assets with their lease-adjusted counterparts. Column (4) uses the jet fuel hedging indicator as the measure of hedging. In each specification, the expected signs for each variable largely match with the empirical results, but there are some notable exceptions within the financial constraints measures.

The initial literature on hedging suggests that more financially constrained firms will hedge more to lower their expected costs of distress. Carter, Rogers, and Simkins (2006) predict negative effects financial constraint variables on hedging. Rampini, Sufi, and Viswanathan (2014), on the other hand, notice that many airlines give financial constraints as a reason not to hedge. They reason that financially constrained airlines, although they may desire to hedge, are unable to do so since they are less likely to have the collateral necessary to finance costly hedging contracts. They would expect a positive relationship between financial constraint variables and hedging.

The estimates for the expected productivity of investment measures - capital expenditures-to-sales and Tobin's Q - generally comport with the Froot, Scharfstein, and Stein (1993) model. Airlines with higher capital expenditures and firm values will hedge more to increase internal funds to invest in more profitable projects. The estimates for variables that are related to financial distress costs, however, mostly follow the Rampini, Sufi, and Viswanathan (2014) theory. Long-term debt-to-assets and credit rating both show negative relationships with the amount of jet fuel hedged. Airlines with more debt and worse credit ratings may not be able to acquire external financing for investment and not have financial collateral to purchase hedging contracts. Log of assets and cash flow-to-sales have positive relationships with hedging. Larger airlines will hedge more, possibly as a result of smaller airlines substituting to less costly forms of jet fuel price risk management such as fuel pass through agreements. Airlines with low cash flow have less ability to buy hedges.

Some variables are omitted from the Carter, Rogers, and Simkins (2006) tests. They drop any variable that does not have at least weak statistical significance in their estimates (these are labeled as “dropped” in Table 4.2), although it is unclear the precise statistical threshold they apply. The thresholds used for this study are discussed in section 4.4.2.1.

4.4.2 Estimated Effects on Jet Fuel Hedging

The same estimation methods that Carter, Rogers, and Simkins (2006) use to determine the factors most associated with jet fuel hedging are employed for this part of the dissertation. The first two estimates use the continuous measure of jet fuel hedging as the dependent variable in a Tobit model. Airlines are not observed increasing their jet fuel price risk by hedging a negative amount of their jet fuel purchases. The hedging variable will be left censored at zero. The third regression applies a logit regression with the indicator variable for jet fuel hedging as the dependent variable.

4.4.2.1 Dropping Statistically Weak Explanatory Variables

As discussed at the end of section 4.4.1, Carter, Rogers, and Simkins (2006) drop any variable with weak statistical significance. However, they do not give an explicit standard or process to determine how statistically insignificant a variable must be to remove it from the final results. In this section, by observing the minimum and maximum p-values for each variable in the three models used, a reasonable criterion to drop insignificant regressors is developed.

The first observation from Table V in Carter, Rogers, and Simkins (2006, p. 69) is that two variables, capital expenditure-to-sales and cash-to-sales, are not statistically significant within at least the 10% level in any of the specifications. The minimum p-values for these two variables are 0.102 and 0.109, respectively, while the maximum p-values are 0.262 and 0.179, respectively. Although these variables do not meet the threshold for statistical significance at standard levels, their p-values may be close enough to be included.

Second, the variables that are statistically significant in at least one of the models have p-values that may vary widely in the others in which the variable is not significant. Long term debt-to-assets is only statistically significant in Model 2 when it is lease adjusted, but highly insignificant in Models 1 and 3 with p-values of 0.579 and 0.619, respectively. Tobin's Q is significant in Models 1 and 2 but insignificant in Model 3 with a 0.413 p-value. The variables do not have to be significant or be "close" to significant in each of the models to be included.

Based on these observations, the following process will be used to obtain the final set of variables in the jet fuel hedging regressions. Each of the variables listed in Table 4.2 are used in the initial model runs.

1. Estimate the models and drop any regressor in which the p-value for each of the three specifications is above 0.400.
2. Rerun the estimates without the dropped variables from the previous step. Drop the regressors from the most current model runs with p-values above 0.400 for all three models, even if the variable met the threshold from a previous model run.
3. The final set of variables are obtained when all of the remaining regressors have a p-value below 0.400 for at least one of the three models.

In the initial model run, three variables displayed weak statistical significance with jet fuel hedging. The jet fuel pass-through agreement indicator (with minimum p-value of 0.998), executive options-to-shares outstanding (0.558), and tax-loss carryforwards-to-asset (0.486) were dropped from the model. In the second run, an additional three variables were found to be highly insignificant: log of assets (minimum p-value of 0.465), executive shares-to-shares outstanding (0.499), and the charter indicator variable (0.454). The third run of the model found no additional statistically weak variables.

4.4.2.2 Final Estimates

The results for the determinants of jet fuel hedging for this dissertation are shown in Table 4.3. A comparison of these results to the theories of hedging is discussed first, followed by a comparison of the estimates from this study and the CRS results.

The variables related to investment opportunities, particularly capital expenditures-to-sales and Tobin's Q, have a consistent positive relationship with hedging which matches the Froot, Scharfstein, and Stein (1993) theoretical framework. Recall that the financial constraint variables may have multiple interpretations based on the theories of Smith and Stulz (1985) and Rampini, Sufi, and Viswanathan (2014). The former argued that firms approaching financial distress will hedge more while the latter realized that firms nearing distress will hedge less or not at all due to lack of collateral to purchase hedging contracts. The tests conducted in this study support Rampini, Sufi, and Viswanathan's (2014) conclusion that financial constraints are associated with less hedging. Long-term debt-to-assets, end year credit rating, and Z-score all have negative and highly statistically significant estimates. Cash-to-sales also marginally supports Rampini, Sufi, and Viswanathan (2014) as cash can be used to hedge. All three estimates are positive but only in the third model is it statistically significant. Cash flow-to-sales has a negative relationship with the amount of hedging (the first two models) but a positive association with the decision to hedge (the third model). However, all three estimates have no statistical relation to hedging.

This study finds little evidence to support the relationship between hedging and tax convexity or managerial incentives. Tax loss carryforwards-to-assets were dropped from the final estimates as were executive shares-to-shares outstanding and executive options-to-shares outstanding. CEO shares-to-shares outstanding and CEO options-to-shares outststanding have negative and positive relationships, respectively, to hedging which is the opposite of what is predicted by Smith and Stulz (1993). However, both CEO shares and CEO options-to-shares outstanding are marginally significant (p-values of 0.083 and 0.121, respectively) in the first model only and highly insignificant in the other two.

Considering other forms of risk management, charter arrangements and fuel pass-through agreements had weak statistical associations with jet fuel hedging and were dropped from the final results. The indicators for interest rate and foreign currency hedges have positive relationships with jet fuel hedging but the only consistently significant estimates are in the third model with the decision to hedge jet fuel (the second model estimates are marginally significant for the interest rate indicator but insignificant for the foreign currency indicator). This suggests that airlines that hedge in one area of risk are more likely to hedge other risks. Hedging against interest rates or foreign currencies is unlikely to affect the amount of jet fuel hedging.

The estimates of the determinants of jet fuel hedging in this study are largely consistent with the Carter, Rogers, and Simkins (2006) results. Both sets of results are consistent with the Froot, Scharfstein, and Stein (1993) theory on hedging in which firms that are more profitable (Tobin's Q) or have more investment opportunities (capital expenditures-to-sales) will hedge more. The earlier Carter, Rogers, and Simkins (2006) time period finds a higher degree of significance in firm profitability than in investment opportunities while the current time frame sees investment opportunities as a more statistically significant factor.

For the variables relating to financial constraints, this study's estimates show a much higher degree of statistical significance in the financial distress regressors such as long-term debt-to assets, end year credit rating, and Z-score. Carter, Rogers, and Simkins (2006) found moderate significance in their credit rating and long-term debt-to-assets estimates while Z-score was too insignificant to include in the final results. In this study, long-term debt-to-assets and credit rating are both highly significant while Z-score is still at least moderately significant in all three models.

Both sets of results find no relation between tax convexity and jet fuel hedging. Managerial compensation incentives have limited explanatory power in the models. Carter, Rogers, and Simkins (2006) only find executive sharesholdings-to-shares outstanding to be significant in their results. This study finds CEO shareholdings-to-shares outstanding to be statistically significance at any standard level.

4.4.3 Summary of Determinants of Jet Fuel Hedging

Section 4.4 of this study finds further empirical evidence that the Rampini, Sufi, and Viswanathan (2014) model relating financial constraints and hedging is correct. More financially constrained airlines, particularly those that are in financial distress or are about to enter distress, are less likely to hedge in both the amount of jet fuel hedging and in their decision to hedge or not. The Froot, Scharfstein, and Stein (1993) framework – firms with higher profitability and more investment opportunities hedge more – is also supported. Similar to Carter, Rogers, and Simkins (2006), tax convexity and managerial compensation are generally insignificant factors in explaining jet fuel hedging by airlines. Finally, the positive and statistically significant relationship between the indicator variables for jet fuel, interest rate, and foreign currency hedges suggests that hedging one type of risk will not crowd out the hedging of other sources of risk. Airlines will attempt to manage jet fuel are just as likely to hedge interest rate, and foreign currency risk.

4.5 Effect of Jet Fuel Hedging on Firm Value

The primary motivation in the Carter, Rogers, and Simkins (2006) study is to analyze how jet fuel hedging by airlines affects the value of the firm. They measure this effect by determining a "hedging premium" – the increase in firm value for an airline that hedges an average amount of its jet fuel requirements compared to an airline that does not hedge any of its fuel requirements.

The nature of the hedging premium is investigated in multiple ways. First, the size of the premium is calculated using multiple estimation methods and hedging measures. Second, additional specifications are tested to account for endogeneity issues between hedging and firm value. The final major test they perform is to establish capital expenditures as the source of the hedging premium in one-stage and two-stage regressions. In each case, a discussion of this study's results is compared to the CRS findings.

4.5.1 Firm Value Models and Specifications

The control variables used in the firm value models of Carter, Rogers, and Simkins (2006) follow closely with the firm value models in Allayannis and Weston (2001). These variables include measures of firm size (log of assets), access to financial markets (indicator for dividends paid), leverage (long-term debt-to-assets), profitability (cash flow-to-sales), investment growth (capital expenditures-to-sales and advertising-to-sales), credit rating, and a set of year dummies.[20] Other variables that Carter, Rogers, and Simkins (2006) use in the models that Allayannis and Weston (2001) do not include cash-to-sales and indicators for other forms of risk management such as fuel passthrough agreements, charter operations, and usage of interest rate derivatives and foreign currency derivatives. The jet fuel hedging measures, both the indicator for a positive amount of jet fuel hedged and the percentage of jet fuel hedged the following year, are the variables of interest.

Carter, Rogers, and Simkins (2006) estimate the model using three estimation methods: pooled ordinary least squares (pooled OLS), fixed effects, and feasible generalized least squares (FGLS). No justification is provided for the fixed effects and FGLS techniques other than as a robustness check on the size and significance of the hedging premium. The indicator for a positive amount of jet fuel hedging is only estimated using pooled OLS. The continuous jet fuel hedging variable is tested using all three estimation procedures.

The model is described by equation (2).

$$V_{it} = \alpha_0 + \beta J_{it} + \gamma X_{it} + u_{it} \tag{2}$$

where *V* is the value of airline *i* at time *t*. *J* is the measure of jet fuel hedging and *X* represents the remaining controls. *u* is the idiosyncratic standard error.

4.5.2 Size of the Hedging Premium

In this study, the same model construction and estimation procedures are followed as described in section 4.5.1. Table 4.4 shows the results of the estimates of jet fuel hedging on firm value described in equation (2). Column (1) displays the pooled OLS estimate for the jet fuel hedge

[20] See section 2.1 of Allayannis and Weston (2001, p. 251-254) for a brief discussion to justify the inclusion of these variables.

indicator. Columns (2), (3), and (4) show the results for the continuous jet fuel hedging variable using pooled OLS, fixed effects, and FGLS, respectively.

The estimates for this study and in Carter, Rogers, and Simkins (2006) are similar. The coefficient of the indicator for positive jet fuel hedging is statistically insignificant in both results. There is no empirical evidence to suggest that an airline's decision to hedge a positive amount of its fuel requirements has any statistical effect on value. However, using the fraction of next year's jet fuel requirements hedged as the measure of hedging, the tests show positive and statistically significant relationships with firm value over all three estimation methods. For the pooled OLS estimate, the average increase in value for each percent of next year's jet fuel requirements hedged is 0.241%. Including only airline-year observations with a positive amount of jet fuel hedging, airlines hedged on average 28.8% of next year's fuel requirements. An airline that hedges the average amount of its future jet fuel requirements over this study's time period can expect an average increase in value of 6.94%. This hedging premium is somewhat smaller than the 10.2% premium found by Carter, Rogers, and Simkins (2006, p. 73). The difference between the hedging premiums comes from the greater effect that each percent of jet fuel hedged adds to value (0.348%) in the CRS data.

The hedging premium found in this study is more robust in the fixed effects and FGLS estimates. The effect that jet fuel hedging has on firm value is only statistically significant using the FGLS estimation procedure in Carter, Rogers, and Simkins (2006) and not significant at any standard level when accounting for airline fixed effects. In this analysis, the coefficients are significant in both fixed effects and FGLS estimates. However, the hedging premium remains smaller in magnitude over all estimates compared to the CRS results.

4.5.3 Possible Endogeneity between Jet Fuel Hedging and Firm Value

Carter, Rogers, and Simkins (2006) express concerns that simultaneous causality bias is present between the firm value and jet fuel hedging measures. They note a positive and statistically significant relationship between jet fuel hedging and firm value in both the jet fuel hedging regressions (Carter, Rogers, and Simkins (2006), Table V, p. 69) and the firm value regressions (Carter, Rogers, and Simkins (2006), Table VI, p. 72). The same issue exists in this study as well, although only the *lease-adjusted* measure of Tobin's Q shows any significance with jet fuel hedging (see column (2) of Table 4.3).

Carter, Rogers, and Simkins (2006) account for the possibility of higher-valued firms hedging more by regressing first differences of the variables. They argue that differences in the jet fuel hedging variables would provide a measure of a change in hedging policy. Changes in hedging policy would be less dependent on firm value than the amount of hedging done. They test this by repeating the jet fuel hedging regressions from Table V (Carter, Rogers, and Simkins (2006), p. 69) using first differences. They find no indication that changes in firm value influence changes in jet fuel hedging behavior. Performing the same analysis in this dissertation, the coefficient for changes in lease-adjusted firm value continues to show a positive and statistically significant effect on changes in percentage of future jet fuel hedged (z-value = 0.004). Concerns with simultaneity bias when considering lease adjustments to firm value may be warranted.

The model with first differences is represented by the following equation.

$$\Delta \log V_{it} = \Delta\alpha_0 + \Delta\beta J_{it} + \Delta\gamma X_{it} + \Delta u_{it} \qquad (3)$$

where *V* is the value of airline *i* at time *t*. *J* is the measure of jet fuel hedging and *X* represents the remaining controls. *u* is the idiosyncratic standard error. Table 4.5 shows the results for the firm value regressions for equation (3). Changes in airlines' decisions to hedge or not shows no statistically significant relationship with changes in firm value as shown in column (1), unlike the positive and significant result found by Carter, Rogers, and Simkins (2006). In column (2), changes in the amount of jet fuel hedged shows a large positive and highly significant effect on changes in value. The expected hedging premium for an airline that changes its percentage of future fuel purchases hedged by the sample average for positive jet fuel hedging years is 10.45%, which is approximately fifty percent larger than the 6.94% premium found in Table 4.4. Carter, Roger, and Simkins (2006) on the other hand, find that the hedging premium decreases from 10.2% in the original firm value regressions (Table VI, p. 72) to 5.5% in the first difference firm value regressions (Table VII, p. 75).

4.5.4 Hedging Premium through Capital Expenditures

Carter, Rogers, and Simkins (2006) further theorize that the source of the hedging premium comes primarily from capital expenditures. That is, airlines that hedge are more likely to have additional cash flow necessary to fund investment. They test this hypothesis in two separate ways. First, an interaction term between capital expenditures-to-sales and the jet fuel hedging variables is added to the regressions, and the hedging premium is evaluated. Second, they perform a two-stage regression in which next year's capital expenditures are predicted by the amount of jet fuel hedging done, then using those predicted values of capital expenditures in the firm value regressions.

4.5.4.1 Interaction of Capital Expenditures with Jet Fuel Hedging

The interaction term with capital expenditures-to-sales and jet fuel hedging is constructed with both the indicator and continuous measures of hedging. Similar to the firm value regressions in section 4.5.2, the interaction term with the indicator measure of hedging is tested only using the pooled OLS estimator, while the term with the continuous measure of hedging is estimated with pooled OLS, fixed effects, and FGLS procedures. The model with this interaction term is as follows.

$$V_{it} = \alpha_0 + \beta J_{it} + \delta J_{it} \times CapX_{it} + \gamma Y_{it} + u_{it} \tag{4}$$

where *V* is the value of the firm for airline *i* at time *t*. *J* is percentage of next year's fuel hedged and *CapX* is the capital expenditure. *Y* represents other controls. *u* is the idiosyncratic error term.

Table 4.6a displays the results for the model described by equation (4). Column (1) shows that the interaction of capital expenditures-to-sales and the indicator for jet fuel hedging has a negative and highly insignificant effect on firm value. This negative coefficient also carries over to the continuous hedging measures in columns (2), (3), and (4), with only the fixed effect estimate being significant at a standard level. This is in stark contrast to the Carter, Rogers, and Simkins (2006) result of a positive and significant effect on firm value. Another point of contrast between the two sets of results is that the estimate for the continuous jet fuel hedging measure is still statistically and economically significant in this analysis, but much smaller in magnitude and largely insignificant over the CRS time period. These results indicate that the hedging premium does not come from capital expenditures at all or may even be reduced by them.

Carter, Rogers, and Simkins (2006) evaluate the total hedging premium in the model by adding together the portion of the premium that comes from capital expenditures and the portion that comes from all other sources.[21] They find the hedging premium to be between 7.2% and 7.8%, with 38% to 86% of the total hedging premium coming from capital expenditures. A similar analysis is performed for each of the estimates from Table 4.6. Using the pooled OLS, fixed effects, and FGLS estimates, the hedging premium evaluates to 7.26%, 8.85%, and 7.74%, respectively, and capital expenditures reduces the total premium by 1.32%, 5.78%, and 1.33%, respectively. Although capital expenditures have a negative effect on the hedging premium, the overall range of the premium remains similar to the premiums of the CRS data.

A major issue with the above analysis is that it does not account for leases. As leases can make up a large portion of an airline's capital expenditures, it is important to examine the interaction of jet fuel hedging and capital expenditures when considering lease adjustments. Table 4.6b displays the estimates for the model using lease-adjusted variables. Each of the coefficients for the interaction terms between jet fuel hedging and capital expenditures becomes positive and statistically significant in each of the three estimation methods. This suggests that hedging airlines are able to increase firm value through capital expenditures primarily by investing in additional leased aircraft. The hedging premium is calculated in the same way as described in footnote 6, except that the average level of capital expenditures becomes 18% after lease adjustments. The value of the hedging premium in the lease-adjusted estimates is generally lower than the non-lease-adjusted estimates: 5.8% for the pooled OLS estimate, 8.42% with

[21] The portion of the hedging premium that comes from capital expenditures is calculated by multiplying the coefficient of the interaction term between jet fuel hedging and capital expenditures-to-sales with the average percentage of future jet fuel requirements hedged over positive hedging airline-years (28.8%) and the average level of capital expenditures-to-sales over the sample (11.6%). The remaining portion of the premium is calculated by multiplying the coefficient of the individual jet fuel hedging term with the average percentage of future jet fuel requirements hedged over positive hedging airline-years.

fixed effects, and 4.47% using FGLS. The fraction of the premium that comes from capital expenditures is also smaller compared to the Carter, Rogers, and Simkins (2006) results; between 21% and 73% of the premium coming from capital expenditures in this analysis.

4.5.4.2 Two-stage Regression of Hedging on Capital Expenditures and Firm Value

The second method applies a two-stage approach to assessing the effect of capital expenditures on the jet fuel hedging premium. Carter, Rogers, and Simkins (2006) reason that current capital expenditures are influenced by the level of jet fuel hedging and firm value from the previous period. The outcome of these investments then influence current period firm value. Empirically, this leads to the following two-stage regressions. In the first regression, they predict the current level of capital expenditures-to-sales from current cash flow-to-sales and one-year lags of Tobin's Q and the percent of jet fuel hedged. The predicted level of capital expenditure-to-sales is subsequently inserted into the firm value regression for the second stage. The process is separately repeated a second time for lease-adjusted values for Tobin's Q and capital expenditures-to-sales. This is represented by the following two equations.

$$\widehat{CapX}_{it} = \alpha_0 + \beta CF_{it} + \gamma J_{i,t-1} + \delta V_{i,t-1} + u_{it} \tag{5}$$

where $\widehat{CapX}$ is predicted capital expenditure, *CF* is cash flow, *V* is lagged firm value, *J* is the lagged percentage of next year's fuel requirements hedged, and *u* is the idiosyncratic error term. Using predicted capital expenditures, the following equation is estimated.

$$V_{it} = \alpha_0 + \beta J_{it} + \delta J_{it} \times \widehat{CapX}_{it} + \gamma Y_{it} + u \tag{6}$$

where *V* is the value of the firm, *J* is the percentage of next year's fuel requirements hedged, $\widehat{CapX}$ is the predicted capital expenditures from equation (5), *Y* represents other controls, and *u* is the idiosyncratic error term.

The results of the two-stage estimation procedure are shown in Table 4.7. Columns (1) and (2) show the first-stage and second-stage estimates, respectively, for the standard measure of Tobin's Q and capital expenditures-to-sales, while columns (3) and (4) show the first-stage and second-stage estimates, respectively, for the lease-adjusted measures of Tobin's Q and capital expenditures-to-sales. Using the standard measure of Tobin's Q and capital expenditures-to-sales, the signs for the coefficients for the jet fuel hedging and the predicted capital expenditures-to-sales variables are both positive, however, the estimate for the predicted capital expenditures-to-sales is statistically insignificant. Considering the lease-adjusted measures for Tobin's Q and capital expenditures-to-sales, the predicted capital expenditures-to-sales coefficient is statistically significant at the 1% level. This provides further evidence that leases are an important factor in capital expenditures' effect on the hedging premium.

The hedging premium for the two-stage model is calculated in a similar fashion to the premium in section 4.5.4.1.[22] Carter, Rogers, and Simkins (2006) find a hedging premium of 20.7% in the non-lease-adjusted estimate and a 6.1% premium from the lease-adjusted regressions. Capital expenditures is responsible for 100% of the former premium but only 65.5% of the latter premium. In this study, the non-lease-adjusted and lease-adjusted premiums are 11.7% and 3.98%, respectively, with capital expenditures responsible for 56.7% and 76.3% of the total premium, respectively.

[22] For this model, the portion that comes from capital expenditures is found by multiplying the coefficient of the lagged jet fuel hedging term in the first-stage regression with the predicted capital expenditures-to-sales coefficient in the second-stage regression and the average percentage of jet fuel hedged for positive hedging airline-years. The remaining portion of the premium comes from the product of the jet fuel hedging coefficient in the second-stage regression and the average percentage of jet fuel hedged for positive hedging airline-years.

4.5.5 Hedging Premium over Time

The final tests that Carter, Rogers, and Simkins (2006) perform seek to evaluate how the hedging premium may change over time, different fuel price regimes, and periods with credit rating upgrades and downgrades. Jet fuel hedging may be more valuable during periods of high volatility compared to low volatility or when external financing may be more difficult to obtain during periods of higher financial constraints. The hedging effects are estimated with interactions between regime dummies and the percent of jet fuel hedged variable using the same model construction from Table VI (Carter, Rogers, and Simkins (2006), p. 72). They consistently find the largest hedging premiums during the 2000-to-2003 time frame. During this period of the sample, prices were the most volatile and airlines experienced a larger number of downgrades in credit rating.

Hedging effects by year for this study are estimated with the same model described above. Table 4.8 shows the yearly hedging coefficients for each year from 1996 to 2014. The years that have positive and statistically significant coefficients in any of the three estimation methods are 2000, 2003, 2008, and 2011-2012. With the exception of 2003, these years generally correspond to times in which jet fuel prices reached a local maximum after rising for one to two prior years with increasing jet fuel prices. This suggests a hedging premium that is larger during times of high volatility. The only observed negative and statistically significant coefficient is for 2009 when jet fuel prices plummeted at the height of the severe financial crisis that began one year earlier in 2008. The most significant effects on the hedging premium occurred when jet fuel prices were more volatile and less significant when prices were relatively stable.

4.6 Jet Fuel Hedging Gains and Losses and Firm Value

Carter, Rogers, and Simkins (2006) conclude their study by noting that the act of hedging alone does not always increase firm value. Jet fuel hedging is more likely to have a positive effect on value when airlines choose an optimal hedging ratio (the fraction of future fuel requirements hedged) that takes advantage of productive investment opportunities when they are available or a general reduction in jet fuel expenditures. Furthermore, airlines only accrue cash flow benefits from hedging when at least some of their hedges have positive value. Thus, airlines that are more successful with their hedges will accumulate greater cash flow than if they were unsuccessful or did not hedge at all. Airline that enjoy large gains from hedges or have successive years of positive gains consequentially have greater incentives to undertake profit-enhancing investments.

In all previous analyses of jet fuel hedging, airlines are assumed to choose optimal hedging ratios and the jet fuel hedges used by airlines have at least zero expected value. This dissertation extends the literature on jet fuel hedging by considering the success or failure of the hedges. In this section, gains and losses from jet fuel hedges are introduced into the firm value models in two ways. First, jet fuel hedging gains and losses are directly inserted into the firm value regressions. Recall from Chapter 3 that hedging gains and losses are separated into four categories: realized, unrealized, ineffective, and no-hedge accounting gains and losses. The regressions control for realized gains and losses from jet fuel hedges because it is the only type of hedging gain or loss that has an effect on the cash flows of the airline. Realized gains and losses are expected to have a positive relationship with firm value.

Another set of regressions is performed using an interaction term between a realized hedging gains and losses indicator and the fraction of next year's jet fuel requirements hedged.

The interaction term describes how the amount of jet fuel hedged affects firm value in years when airlines record successful jet fuel hedges. The hedging premium for years when jet fuel hedging is successful can be compared to the premium during all years.

For all regressions in this section, the sample time frame becomes 2001-2014. Jet fuel hedging gains and losses data are unreliable and inconsistently reported prior to the passage of FAS 133 in June 1998, and most airlines did not fully adopt FAS 133 until January 2001. Changing the time period ensures that jet fuel hedging data used in the tests are consistent over the entire sample. To get a consistent comparison of the hedging premiums for the successful jet fuel hedging years and the entire time period, the model from Table 4.4 using the fraction of next year's fuel requirements hedged is re-estimated for the new time period.

4.6.1 Jet Fuel Hedging Realized Gains and Losses and Firm Value

To test the relationship between successful jet fuel hedging and firm value, the same controls from the firm value model from Table 4.4 are used. The fraction of next year's fuel requirements hedged variable is dropped, and the realized gains and losses variable is added to the model. This model is described by the following equation.

$$\log V_{it} = \alpha_0 + \beta GL_{it} + \gamma X_{it} + u_{it} \tag{7}$$

where *V* is the value of airline *i* at time *t*, *GL* is realized gains and losses from jet fuel hedging, and *X* represents the remaining controls. *u* is the idiosyncratic standard error. Table 4.9a presents the estimates of equation (7) using pooled OLS, fixed effects, and FGLS estimation methods in column (1), column (2), and column (3), respectively. The coefficient for the realized gains and losses variable is negative in all three estimation procedures. The realized gains and losses coefficient is statistically significant at the 5% level in the pooled OLS estimate but statistically insignificant in the fixed effects and FGLS estimates.

Why is the sign of the coefficient on the jet fuel hedging gains and losses variable negative when the expected relationship is positive? This counterintuitive result is investigated in multiple ways. First, a comparison of Table 4.6a and Table 4.6b shows that leases influence the hedging premium. In untabulated results, when lease-adjusted variables for firm value and other controls are used, the realized gains and losses coefficient becomes statistically insignificant for all estimates but remains negative.

Second, outliers in the realized gains and losses variable may influence its relationship with firm value. Figure 4.1 shows a box plot of non-zero realized gains and losses from jet fuel hedging. The box plot is constructed in the standard way, with the whiskers extending 1.5 times the interquartile range from the first and third quartiles.[23] Data points outside these whiskers constitute outliers. Of the eleven outliers that are negative, eight of these are from the years 2009 and 2010 when jet fuel prices fell considerably and all hedging firms suffered large losses. Five of the nine outliers that are positive come during Southwest's run of extraordinary hedging success from 2004 to 2008 which no other airline was able to produce. Eliminating these outliers from the model estimates may give a more reasonable look at the relationship between jet fuel hedging gains and losses and the value of the firm.

Table 4.9b shows the results of the estimation of equation (7) after removing outliers from the sample. Although none of the estimates are statistically significant, all the coefficients

[23] The first and third quartiles are -7 and 79, respectively, implying an interquartile range of 86. Applying the interquartile rule, the ends of the left whisker and right whisker are -136 ($-7 - 1.5 \times 86$) and 208 ($79 + 1.5 \times 86$), respectively.

show a positive relationship with firm value. In untabulated results, using lease-adjusted variables, the coefficients remain positive and statistically insignificant. The method for identifying outliers is adjusted by increasing the range of the whiskers of the box plot to 2 times and 3 times the interquartile range. Estimating the model after eliminating outliers that are outside 2 times the interquartile range still gives a positive coefficient on realized gains and losses from jet fuel hedging. However, the coefficient becomes negative and statistically insignificant after raising the outlier identification threshold to 3 times the interquartile range. The negative coefficient on realized gains and losses found in Table 4.9a is most likely driven by the significant losses airlines suffered during the recession that began in 2009.

4.6.2 Measurement of the Hedging Premium for Successful Jet Fuel Hedging

Recall that the hedging premium for jet fuel describes the increase in firm value that an airline will experience when it hedges an average amount of its jet fuel requirements for the following year compared to an airline that does not hedge at all. This hedging premium is almost certainly influenced by the success or failure of its jet fuel hedges. If two airlines hedge the same fraction of their future jet fuel requirements, the airline that is more successful in its hedging activities will have more cash flow to fund investment compared to an airline that has less successful hedges. The estimation results from the previous section show that successful hedging is associated with lower firm values. Therefore, the hedging premium may be smaller during years of successful jet fuel hedging.

The firm value model from Table 4.4 is adjusted to add an interaction term between the fraction of next year's jet fuel requirements hedged and an indicator for jet fuel hedging realized gains (i.e., the indicator variable is one when realized gains and losses variable is positive, zero otherwise) in the current year. Table 4.10 shows the results of these regressions. The coefficients on both the jet fuel hedging variable and the interaction term between hedging and positive gains indicator is positive and statistically insignificant at standard levels. The hedging premium for during years in which hedging is successful is approximately 5.6% in pooled OLS estimate and 7.2% in the FGLS estimate.[24] In untabulated results, the jet fuel hedging coefficient for the original firm value model (Table 4.4) using the adjusted time frame is 0.312 and 0.371 in the pooled OLS and FGLS estimates, respectively. These hedging coefficients imply a hedging premium of 9.2% and 10.9%, respectively. The hedging premium when jet fuel hedging gains and losses are positive is approximately 3% to 4% smaller than the hedging premium over the entire adjusted time frame.

4.7 Conclusion

Carter, Rogers, and Simkins (2006) is one of the seminal papers on the empirical study of hedging. They establish that the airline industry is a most suitable environment to study hedging because of airlines' exposure to jet fuel price risk and its ideal investment setting matches the leading theories on hedging and firm value. They determine that the hedging premium for airlines that hedge jet fuel versus those that do not falls in a range between 5% and 10%. Furthermore, they also show that a large portion, between 65% and 86%, of the hedging premium comes from capital expenditures.

In this chapter, a reproduction of the Carter, Rogers, and Simkins (2006) hedging models is performed using a more recent dataset over a time ranging from 1995 to 2014. Evidence is found that verifies the Rampini, Sufi, and Viswanathan (2014) model on the determinants of jet

[24] Jet fuel hedging gains are positive in 36.8% of all observations and the average jet fuel requirements hedged is 16.2%. The hedging premium is calculated to be $(0.141\times0.294 + 0.136\times0.368\times0.294) = 0.031$ and $(0.172\times0.294 + 0.194\times0.368\times0.294) = 0.039$ for the pooled OLS and FGLS estimates, respectively.

fuel hedging; that is, more financially constrained firms hedge less rather than more because they do not have the collateral necessary to purchase costly hedging contracts. The hedging premium in this empirical analysis is found to be 6.9%, 3.3% smaller than the hedging premium found by Carter, Rogers, and Simkins (2006). This study additionally finds a negative association between firm value and the interaction of capital expenditures and hedging, however, this relationship becomes positive when accounting for lease adjustments in both the one-stage and two-stage regression models. This suggests that leasing aircraft is important to an airline's overall capital expenditures and its effect on firm value.

This chapter contributes to the economic literature on hedging by introducing jet fuel hedging gains and losses into the firm value models, rather than simply relying on the fraction of total jet fuel requirements hedged as has been done in previous studies. Successful jet fuel hedging is shown to have a negative relationship on firm value. This counterintuitive result may be explained by the significant losses suffered by airlines during the recession in 2009. Eliminating outliers from the sample using the interquartile rule with a standard box plot results in a positive relationship between firm value and realized gains and losses. This chapter continues to find a smaller, but still positive and statistically significant, hedging premium. Hedging airlines have higher values compared to airlines that do not hedge jet fuel at all.

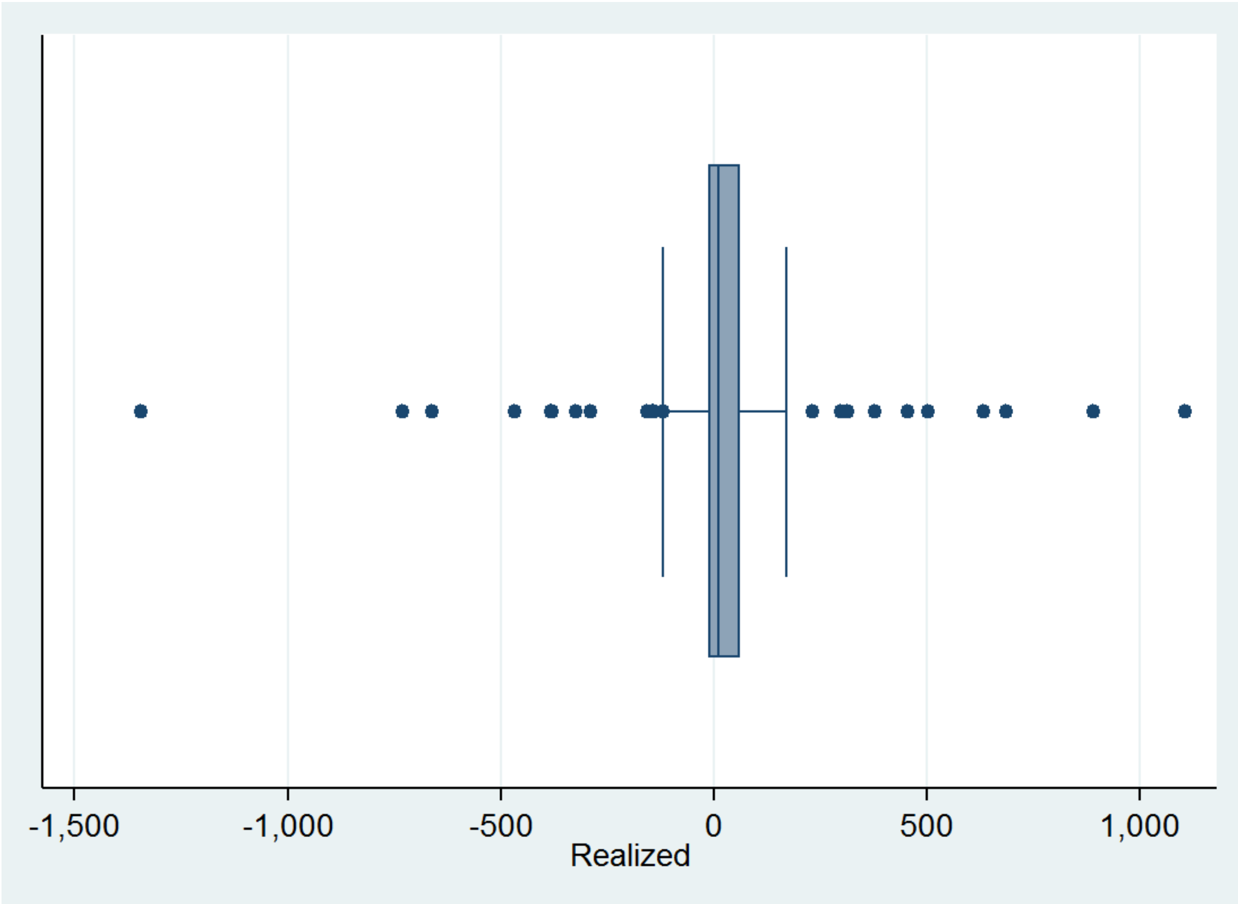

Figure 4.1: Box Plot of Realized Gains and Losses (Millions) from Jet Fuel Hedging (Non-zero Values)

Notes: This figure shows a box plot of realized gains and losses from jet fuel hedges. Gains and losses are measured in millions. The lower and upper limits are 1.5 times the interquartile range from the first and third quartiles.

Table 4.1: Summary Statistics Used in Replication Regressions

VARIABLES	(1) Obs.	(2) Mean	(3) St. Dev.	(4) Min	(5) Max	(6) CRS mean
Fraction of next year's fuel requirements hedged	284	0.148	0.203	0.000	0.950	0.109
Positive fraction of fuel hedged indicator	284	0.514	0.501	0.000	1.000	0.370
Capital expenditures-to-sales	319	0.116	0.178	-0.010	2.233	0.117
Tobin's Q	313	0.621	0.509	-0.240	3.788	0.955
Long-term debt-to-assets	322	0.310	0.195	0.000	1.300	0.266
Log of assets	322	7.611	1.961	2.621	10.900	6.843
Capital expenditures-to-sales (lease-adjusted)	306	0.180	0.455	-2.790	2.487	0.273
Tobin's Q (lease-adjusted)	305	1.051	0.256	0.214	2.363	0.962
Long-term debt-to-assets (lease-adjusted)	309	0.626	0.179	0.000	1.043	0.577
Log of assets (lease-adjusted)	309	8.445	1.733	4.163	11.110	7.498
Cash flow-to-sales	321	0.053	0.136	-1.169	1.229	0.049
Cash-to-sales	321	0.116	0.113	0.000	1.195	0.152
Advertising-to-sales	204	0.013	0.012	0.000	0.121	-
End of year credit rating	306	21.62	7.507	8.000	30.000	22.278
Z-score	321	1.572	1.283	-1.657	7.917	2.035
Tax loss carryforwards-to-assets	204	0.127	0.172	0.000	1.263	0.110
Dividends indicator	321	0.302	0.460	0.000	1.000	0.297
Executive options-to-shares outstanding	209	0.005	0.007	0.000	0.045	0.046
Executive shares-to-shares outstanding	209	0.011	0.017	0.000	0.100	0.071
CEO options-to-shares outstanding	187	0.002	0.003	0.000	0.016	0.022
CEO shares-to-shares outstanding	187	0.009	0.015	0.000	0.077	0.035
Fuel pass-through indicator	287	0.209	0.407	0.000	1.000	0.222
Charter indicator	291	0.357	0.480	0.000	1.000	0.455
Foreign currency hedge indicator	291	0.216	0.413	0.000	1.000	0.230
Interest rate hedge indicator	291	0.316	0.466	0.000	1.000	0.258

Notes: The time period for the more recent data is from 1995 to 2014. Column (1) gives the number of observations for each variable, column (2) provides the mean, column (3) shows the standard deviation, column (4) shows the minimum value, column (5) gives the maximum value, and column (6) displays the mean values of the variables from the Carter, Rogers, and Simkins (2006) summary statistics table (Table IV, p. 67). The time frame of these means is 1992 to 2003.

Table 4.2: Carter, Rogers, and Simkins (2006) Table V Expected Signs and Results

Variable	(1) Expected sign	(2) Fraction of Jet Fuel Hedged	(3) Fraction of Jet Fuel Hedged (Lease-adjusted)	(4) Fuel Hedge Indicator
A. Financial constraints				
Capital expenditures	+	+		+
Tobin's Q	+	+		+
Long-term debt	+	-		+
Log of assets	-	+		+
Capital expenditures (lease)	+		+	
Tobin's Q (lease)	+		+	
Long-term debt (lease)	+		-	
Log assets (lease)	-		+	
Cash flow	-	+	+	+
Cash	-	-	-	-
Credit rating	+	-	-	-
Dividends indicator	N/A	Dropped	Dropped	Dropped
Z-score	+	Dropped	Dropped	Dropped
B. Tax Convexity				
Tax loss carryforwards	+	Dropped	Dropped	Dropped
C. Managerial incentives				
Exec. shares	+	+	+	+
CEO shares	+	Dropped	Dropped	Dropped
Exec. options	-	Dropped	Dropped	Dropped
CEO options	-	Dropped	Dropped	Dropped
D. Other risk management				
Fuel pass through	-	-	-	-
Charter	-	Dropped	Dropped	Dropped
Foreign currency	-	Dropped	Dropped	Dropped
Interest rate	-	+	+	+

Notes: This table provides the expected relationship between the given variables and jet fuel hedging as described by Carter, Rogers, and Simkins (2006). Cells with "+" indicate a positive relationship with jet fuel hedging. Cells with "-" indicate a negative relationship with jet fuel hedging. Cells that contain "Dropped" indicate that the variable was not included in Table V of Carter, Rogers, and Simkins (2006, p. 69).

Table 4.3: Factors That Influence Jet Fuel Hedging by Airlines

VARIABLES	(1) Random Effects Tobit	(2) Random Effects Tobit	(3) Random Effects Logit
Capital expenditures-to-sales	0.557***		10.41***
	(0.0017)		(0.010)
Tobin's Q (Adjusted)	0.0538		0.670
	(0.389)		(0.610)
Long-term debt-to-assets	-0.660***		-19.03***
	(0.000)		(0.001)
Cash flow-to-sales	-0.0644	-0.155	3.675
	(0.589)	(0.177)	(0.658)
Cash-to-sales	0.265	0.445*	2.065
	(0.162)	(0.052)	(0.756)
End of year credit rating	-0.0268***	-0.0265***	-0.372***
	(0.000)	(0.000)	(0.001)
Interest rate hedge indicator	0.0410	0.0603*	3.967***
	(0.232)	(0.098)	(0.003)
CEO shares-to-shares outstanding	-3.215*	-0.109	-31.17
	(0.083)	(0.952)	(0.371)
CEO options-to-shares outstanding	13.11	8.412	51.81
	(0.121)	(0.342)	(0.805)
Dividends indicator	-0.0913**	-0.0460	-4.615***
	(0.013)	(0.418)	(0.001)
Z-score	-0.0913**	-0.0683*	-3.895***
	(0.013)	(0.0958)	(0.005)
Foreign currency hedge indicator	0.0199	0.0229	2.572*
	(0.689)	(0.663)	(0.061)
Capital expenditures-to-sales (l/a)		0.0397	
		(0.630)	
Tobin's Q (l/a)		0.258**	
		(0.011)	
Long-term debt-to-assets (l/a)		-0.614***	
		(0.001)	
Constant	0.686***	0.493***	12.81***
	(0.000)	(0.006)	(0.000)
Observations	175	175	175
Number of airlines	13	13	13

Notes: This table shows the regression results for the determinants of jet fuel hedging by airlines. The dependent variable in columns (1) and (2) is the fraction of expected jet fuel requirements hedged and an indicator for positive jet fuel hedging as the dependent variable for column (3). All regressions contain year dummies. P-values are in parenthesis. (l/a) indicates the variable is lease-adjusted. Statistical significance at the 10%, 5%, and 1% levels are denoted by *, **, and ***, respectively.

Table 4.4: Firm Value on Jet Fuel Hedging Regressions

VARIABLES	(1) Pooled OLS	(2) Pooled OLS	(3) Fixed Effects	(4) FGLS
Log of assets	0.0184	0.0144	0.0573	0.0909***
	(0.821)	(0.862)	(0.501)	(0.000)
Dividends indicator	0.102	0.103	-0.0196	0.0589
	(0.110)	(0.103)	(0.781)	(0.195)
Long-term debt-to-assets	1.423***	1.486***	2.321***	1.760***
	(0.001)	(0.001)	(0.000)	(0.000)
Cash flow-to-sales	1.212*	1.162	-0.182	0.402*
	(0.084)	(0.100)	(0.463)	(0.0710)
Capital expenditures-to-sales	0.256	0.214	0.357*	0.376***
	(0.171)	(0.255)	(0.087)	(0.002)
Z-score	0.165	0.171	0.659***	0.403***
	(0.406)	(0.391)	(0.000)	(0.000)
End of year credit rating	-0.0112	-0.00802	0.0072	-0.0060
	(0.156)	(0.318)	(0.419)	(0.232)
Advertising-to-sales	23.62***	23.70***	25.96***	25.09***
	(0.000)	(0.000)	(0.000)	(0.000)
Cash-to-sales	0.134	0.0821	0.0075	-0.239
	(0.669)	(0.795)	(0.980)	(0.217)
Positive fraction of fuel hedged indicator	0.0303			
	(0.673)			
Charter indicator	-0.0721	-0.0706	0.0206	0.0399
	(0.331)	(0.340)	(0.809)	(0.456)
Fuel pass-through indicator	0.922**	0.904**		
	(0.012)	(0.0153)		
Interest rate hedge indicator	-0.0458	-0.0567	-0.0056	-0.0689**
	(0.255)	(0.160)	(0.906)	(0.033)
Foreign currency hedge indicator	-0.0324	-0.0059	0.0276	-0.0434
	(0.701)	(0.942)	(0.710)	(0.364)
Fraction of next year's fuel requirements hedged		0.241*	0.248**	0.261***
		(0.059)	(0.0261)	(0.005)
Constant	-0.724	-0.764	-2.251**	-1.875***
	(0.545)	(0.526)	(0.012)	(0.000)
Observations	183	183	183	183
R-squared	0.727	0.732	0.765	
Number of airlines			16	16

Notes: This table displays the results of the effect that jet fuel hedging has on firm value. The dependent variable for each of the four columns is the log of Tobin's Q, the proxy for firm value. All regressions contain year dummies. P-values are in parenthesis. Statistical significance at the 10%, 5%, and 1% levels are denoted by *, **, and ***, respectively.

Table 4.5: Firm Value Regressions with First Differences

VARIABLES	(1) Pooled OLS	(2) Pooled OLS
Δ Log of assets	0.250*	0.229
	(0.086)	(0.108)
Δ Dividends indicator	0.0117	0.0691
	(0.892)	(0.363)
Δ Long-term debt-to-assets	2.564***	2.586***
	(0.000)	(0.000)
Δ Cash flow-to-sales	-0.0166	0.0012
	(0.952)	(0.996)
Δ Capital expenditures-to-sales	0.227	0.187
	(0.569)	(0.617)
Δ Z-score	0.394***	0.379***
	(0.000)	(0.000)
Δ End of year credit rating	0.0068	0.0045
	(0.602)	(0.724)
Δ Advertising-to-sales	20.56**	25.00***
	(0.023)	(0.005)
Δ Cash-to-sales	-0.252	-0.254
	(0.394)	(0.332)
Δ Positive fraction of fuel hedged indicator	0.0382	
	(0.398)	
Δ Charter indicator	0.156*	0.131*
	(0.064)	(0.083)
Δ Interest rate hedge indicator	0.0550	0.0381
	(0.501)	(0.622)
Δ Foreign currency hedge indicator	-0.0222	-0.0005
	(0.757)	(0.995)
Δ Fraction of next year's fuel requirements hedged		0.363***
		(0.003)
Constant	0.441***	0.456***
	(0.000)	(0.000)
Observations	165	165
R-squared	0.610	0.640

Notes: This table reports the results for the effect of the change in firm value on the change in jet fuel hedging. The dependent variable for each regression is the log of Tobin's Q. All regressions contain year dummies. P-values are in parenthesis. Statistical significance at the 10%, 5%, and 1% levels are denoted by *, **, and ***, respectively.

Table 4.6a: Interaction of Capital Expenditures-to-sales on Jet Fuel Hedging

VARIABLES	(1) Pooled OLS	(2) Pooled OLS	(3) Fixed Effects	(4) FGLS
Log of assets	0.0185	0.0149	0.0552	0.0921***
	(0.822)	(0.860)	(0.513)	(0.000)
Dividends indicator	0.105*	0.108*	0.0163	0.0647
	(0.095)	(0.072)	(0.823)	(0.167)
Long-term debt-to-assets	1.422***	1.479***	2.291***	1.750***
	(0.001)	(0.001)	(0.000)	(0.000)
Cash flow-to-sales	1.222*	1.174*	-0.167	0.404*
	(0.082)	(0.099)	(0.497)	(0.071)
Capital expenditures-to-sales	0.374	0.326	0.849**	0.507*
	(0.531)	(0.447)	(0.016)	(0.093)
Z-score	0.163	0.169	0.670***	0.404***
	(0.409)	(0.395)	(0.000)	(0.000)
End of year credit rating	-0.0108	-0.0072	0.0114	-0.0049
	(0.218)	(0.448)	(0.213)	(0.391)
Advertising-to-sales	23.77***	23.84***	27.14***	25.16***
	(0.000)	(0.000)	(0.000)	(0.000)
Cash-to-sales	0.141	0.106	0.124	-0.203
	(0.661)	(0.755)	(0.685)	(0.312)
Positive fraction of fuel hedged indicator	0.0458			
	(0.727)			
Charter indicator	-0.0789	-0.0792	-0.0045	0.0313
	(0.354)	(0.337)	(0.959)	(0.573)
Fuel pass-through indicator	0.931***	0.912**		
	(0.009)	(0.013)		
Interest rate hedge indicator	-0.0465	-0.0596	-0.0088	-0.0700**
	(0.248)	(0.128)	(0.850)	(0.033)
Foreign currency hedge indicator	-0.0292	0.0024	0.0602	-0.0349
	(0.712)	(0.974)	(0.429)	(0.489)
Fuel hedged indicator × capital expenditures	-0.143			
	(0.842)			
Fraction of next year's fuel requirements hedged		0.298	0.508***	0.315**
		(0.211)	(0.007)	(0.047)
Fraction fuel hedged × capital expenditures		-0.395	-1.729*	-0.399
		(0.766)	(0.081)	(0.649)
Constant	-0.743	-0.795	-2.409***	-1.925***
	(0.552)	(0.530)	(0.007)	(0.000)
Observations	183	183	183	183
R-squared	0.727	0.732	0.771	
Number of airlines			16	16

Notes: This table shows the results for regressions that explain the influence that jet fuel hedging has on firm value through capital expenditures. The dependent variable for all regressions is the log of Tobin's Q. All regressions contain year dummies. P-values are in parenthesis. Statistical significance at the 10%, 5%, and 1% levels are denoted by *, **, and ***, respectively.

Table 4.6b: Interaction of Capital Expenditures-to-sales (Lease Adjusted) on Jet Fuel Hedging

VARIABLES	(1) Pooled OLS	(2) Pooled OLS	(3) Fixed Effects	(4) FGLS
Log of assets (l/a)	-0.0279	-0.0275	-0.0114	-0.0113
	(0.381)	(0.427)	(0.790)	(0.344)
Dividends indicator	0.0693**	0.0756***	0.0639*	0.0666***
	(0.024)	(0.004)	(0.086)	(0.006)
Long-term debt-to-assets (l/a)	0.731***	0.860***	1.384***	0.857***
	(0.000)	(0.000)	(0.000)	(0.000)
Cash flow-to-sales	0.339	0.375	-0.0035	0.100
	(0.220)	(0.196)	(0.978)	(0.277)
Capital expenditures-to-sales (l/a)	-0.181***	-0.0523	-0.0325	-0.0610*
	(0.007)	(0.469)	(0.541)	(0.092)
Z-score	0.0752	0.0616	0.117***	0.113***
	(0.197)	(0.326)	(0.001)	(0.000)
End of year credit rating	-0.0106***	-0.0084***	-0.0092*	-0.0084***
	(0.004)	(0.004)	(0.051)	(0.000)
Advertising-to-sales	12.09***	11.87***	14.12***	10.68***
	(0.000)	(0.000)	(0.000)	(0.000)
Cash-to-sales	-0.0637	-0.0847	-0.0311	-0.146
	(0.702)	(0.624)	(0.844)	(0.168)
Positive fraction of fuel hedged indicator	-0.0453			
	(0.299)			
Charter indicator	0.0121	0.0058	0.0487	0.0176
	(0.675)	(0.832)	(0.274)	(0.479)
Fuel pass-through indicator	0.267**	0.231*		0
	(0.021)	(0.060)		
Interest rate hedge indicator	-0.0348	-0.0279	-0.0062	-0.0130
	(0.202)	(0.299)	(0.801)	(0.382)
Foreign currency hedge indicator	-0.0075	-0.0150	0.0149	0.0010
	(0.892)	(0.790)	(0.704)	(0.964)
Fuel hedged indicator × capital expenditures (l/a)	0.332***			
	(0.002)			
Fraction of next year's fuel requirements hedged		0.119	0.231***	0.0420
		(0.242)	(0.002)	(0.446)
Fraction fuel hedged × capital expenditures (l/a)		0.458**	0.341*	0.628***
		(0.019)	(0.085)	(0.000)
Constant	0.154	0.0321	-0.467	-0.183
	(0.731)	(0.949)	(0.290)	(0.263)
Observations	183	183	183	183
R-squared	0.741	0.731	0.775	
Number of airlines			16	16

Notes: This table presents the results for regressions that show the effect of jet fuel hedging has on firm value through lease-adjusted capital expenditures. The dependent variable for each regression is the log of Tobin's Q adjusted by leases. All regressions contain year dummies. P-values are in parenthesis. (l/a) indicates the variable is lease-adjusted. Statistical significance at the 10%, 5%, and 1% levels are denoted by *, **, and ***, respectively.

Table 4.7: Two-stage Regression of Predicted Capital Expenditures on Firm Value

VARIABLES	(1) CapX	(2) ln(Q)	(3) Cap(lease-adjusted)	(4) ln(Q)(lease-adjusted)
Log of assets		0.0164		-0.0102
		(0.830)		(0.713)
Dividends indicator		0.0405		-0.0206
		(0.526)		(0.692)
Long-term debt-to-assets		1.431***		0.430**
		(0.003)		(0.012)
Cash flow-to-sales	0.0861*	0.786	0.360	-0.391*
	(0.077)	(0.233)	(0.122)	(0.056)
Capital expenditures-to-sales predicted		2.217		
		(0.259)		
Z-score		0.131		0.0808
		(0.482)		(0.260)
End of year credit rating		-0.0054		-0.0013
		(0.497)		(0.749)
Advertising-to-sales		24.49***		7.146***
		(0.000)		(0.001)
Cash-to-sales		0.245		0.120
		(0.475)		(0.425)
Fraction of next year’s fuel requirements hedged		0.176		0.0327
		(0.311)		(0.640)
Charter indicator		-0.0753		0.0001
		(0.402)		(0.998)
Interest rate hedge indicator		-0.0541		-0.0184
		(0.207)		(0.491)
Foreign currency hedge indicator		-0.0116		-0.0185
		(0.890)		(0.776)
Log of Tobin’s Q lagged	0.0531***			
	(0.001)			
Fraction of next year’s fuel requirements hedged lagged	0.104***		0.0822	
	(0.001)		(0.412)	
Log of Tobin’s Q (l/a) lagged			0.293***	
			(0.009)	
Capital expenditures-to-sales (l/a) predicted				1.283***
				(0.000)
Constant	0.0980***	-0.924	0.116***	-0.0400
	(0.000)	(0.375)	(0.007)	(0.921)
Observations	263	169	263	169
R-squared	0.113	0.733	0.051	0.729

Notes: This table provides the results for two-stage regressions for the effect of jet fuel hedging on firm value through capital expenditures. Column (1) shows the first-stage regression of capital expenditures-to-sales on cash flow-to-sales, the lag of the fraction of next year’s jet fuel requirements hedged, and the lag of Tobin’s Q. Column (2) displays the second-stage regression results of firm value on the predicted capital expenditures-to-sales. Columns (3) and (4) show the results of regressions using lease-adjusted (l/a) vaiables. All regressions contain year dummies. P-values are in parenthesis. Statistical significance at the 10%, 5%, and 1% levels are denoted by *, **, and ***, respectively.

Table 4.8: Effect of Jet Fuel Hedging on Firm Value by Year

Year	(1) Pooled OLS	(2) Fixed Effects	(3) FGLS
1996	1.352	0.773	1.336
	(0.181)	(0.659)	(0.302)
1997	0.726	0.856	0.355
	(0.176)	(0.225)	(0.522)
1998	0.0628	-0.0128	0.0639
	(0.840)	(0.961)	(0.776)
1999	0.333	0.491	0.420
	(0.232)	(0.204)	(0.162)
2000	0.701	0.566*	0.756***
	(0.136)	(0.052)	(0.005)
2001	-0.124	-0.138	0.374
	(0.873)	(0.743)	(0.394)
2002	0.189	-0.0090	0.206
	(0.269)	(0.973)	(0.419)
2003	0.429*	0.211	0.352
	(0.0943)	(0.477)	(0.172)
2004	-0.0068	0.0664	0.0248
	(0.981)	(0.803)	(0.910)
2005	-0.816	-0.0611	-0.149
	(0.178)	(0.858)	(0.596)
2006	0.0174	-0.0273	0.0062
	(0.915)	(0.924)	(0.980)
2007	-0.0700	0.135	0.0843
	(0.806)	(0.752)	(0.810)
2008	2.180	1.744***	0.966***
	(0.104)	(0.000)	(0.009)
2009	-0.543*	-0.614	-0.376
	(0.084)	(0.164)	(0.302)
2010	0.125	0.637	0.499
	(0.752)	(0.176)	(0.218)
2011	0.444	1.089**	1.082***
	(0.458)	(0.032)	(0.008)
2012	0.599*	1.117**	0.915**
	(0.089)	(0.036)	(0.024)
2013	0.351	0.440	0.532
	(0.349)	(0.547)	(0.329)
2014	-0.193	-0.133	0.0341
	(0.540)	(0.839)	(0.939)
Constant	-1.481	-3.193***	-2.676***
	(0.189)	(0.000)	(0.000)
Observations	183	183	183
R-squared	0.775	0.813	
Number of airlines		16	16

Notes: This table shows the results of the firm value regressions from columns (2), (3), and (4) from Table 4.4 with the interaction of year dummies with the fraction of next year's jet fuel requirements hedged. Only the coefficients of the interaction terms for each year are reported. All regressions contain year dummies. P-values are in parenthesis. Statistical significance at the 10%, 5%, and 1% levels are denoted by *, **, and ***, respectively.

Table 4.9a: Firm Value on Jet Fuel Hedging Gains and Losses Regressions

VARIABLES	(1) Pooled OLS	(2) Fixed Effects	(3) FGLS
Log of assets	0.0049	0.185	0.0851**
	(0.948)	(0.117)	(0.014)
Dividends indicator	0.0555	-0.177*	-0.0067
	(0.532)	(0.080)	(0.913)
Long-term debt-to-assets	1.786***	2.753***	1.862***
	(0.000)	(0.000)	(0.000)
Cash flow-to-sales	2.357**	0.498	1.140***
	(0.013)	(0.359)	(0.008)
Capital expenditures-to-sales	-0.110	0.438*	0.200
	(0.667)	(0.085)	(0.222)
Z-score	-0.0546	0.485***	0.275***
	(0.780)	(0.001)	(0.000)
End of year credit rating	-0.0160*	0.0012	-0.0106
	(0.0946)	(0.923)	(0.121)
Advertising-to-sales	31.03***	48.73***	28.25***
	(0.000)	(0.000)	(0.000)
Cash-to-sales	0.442	0.302	0.244
	(0.243)	(0.386)	(0.309)
Charter indicator	-0.0376	0.0107	0.0348
	(0.615)	(0.942)	(0.559)
Interest rate hedge indicator	0.0316	0.0361	-0.0055
	(0.558)	(0.575)	(0.888)
Foreign currency hedge indicator	-0.177**	-0.0469	-0.188***
	(0.040)	(0.670)	(0.001)
Realized Gains and Losses	-0.00020**	-0.000072	-0.000134
	(0.011)	(0.577)	(0.166)
Constant	-0.429	-3.270***	-1.578***
	(0.689)	(0.006)	(0.001)
Observations	120	120	120
R-squared	0.717	0.778	
Number of airlines		14	14

Notes: This table reports the results of the effect that realized gains and losses from jet fuel hedging has on firm value. The dependent variable for each of the three columns is the log of Tobin's Q, the proxy for firm value. All regressions contain year dummies. P-values are in parenthesis. Statistical significance at the 10%, 5%, and 1% levels are denoted by *, **, and ***, respectively.

Table 4.9b: Firm Value on Jet Fuel Hedging Gains and Losses Regressions (Excluding Outliers)

VARIABLES	(1) Pooled OLS	(2) Fixed Effects	(3) FGLS
Log of assets	-0.0026	0.208	0.0894**
	(0.973)	(0.130)	(0.030)
Dividends indicator	0.0639	-0.142	0.0354
	(0.528)	(0.204)	(0.627)
Long-term debt-to-assets	1.813***	2.923***	2.038***
	(0.000)	(0.000)	(0.000)
Cash flow-to-sales	2.239**	0.256	0.821*
	(0.026)	(0.679)	(0.096)
Capital expenditures-to-sales	-0.110	0.495*	0.266
	(0.684)	(0.078)	(0.133)
Z-score	-0.0594	0.574***	0.358***
	(0.783)	(0.001)	(0.000)
End of year credit rating	-0.0158	0.0053	-0.0146*
	(0.114)	(0.716)	(0.055)
Advertising-to-sales	31.15***	44.17***	27.86***
	(0.000)	(0.001)	(0.000)
Cash-to-sales	0.436	0.208	0.0926
	(0.329)	(0.606)	(0.748)
Charter indicator	-0.0393	0.0356	0.109
	(0.692)	(0.834)	(0.139)
Interest rate hedge indicator	0.0337	0.0459	0.0051
	(0.578)	(0.558)	(0.910)
Foreign currency hedge indicator	-0.184*	-0.0176	-0.209***
	(0.0690)	(0.898)	(0.00318)
Realized Gains and Losses	0.000083	0.000212	0.000473
	(0.889)	(0.747)	(0.310)
Constant	-0.343	-3.704***	-1.728***
	(0.753)	(0.007)	(0.002)
Observations	102	102	102
R-squared	0.709	0.790	
Number of airlines		14	14

Notes: This table reports the results of the effect that realized gains and losses from jet fuel hedging has on firm value. The dependent variable for each of the three columns is the log of Tobin's Q, the proxy for firm value. All regressions contain year dummies. P-values are in parenthesis. Statistical significance at the 10%, 5%, and 1% levels are denoted by *, **, and ***, respectively.

Table 4.10: Firm Value Regressions with Interaction of Jet Fuel Hedging and Successful Hedging

VARIABLES	(2) Pooled OLS	(3) Fixed Effects	(4) FGLS
Log of assets	-0.0252	0.171	0.0509
	(0.735)	(0.146)	(0.133)
Dividends indicator	0.0575	-0.176*	0.0303
	(0.507)	(0.077)	(0.607)
Long-term debt-to-assets	1.925***	2.889***	2.129***
	(0.000)	(0.000)	(0.000)
Cash flow-to-sales	2.027**	0.399	0.745*
	(0.030)	(0.448)	(0.064)
Capital expenditures-to-sales	-0.159	0.376	0.123
	(0.562)	(0.149)	(0.475)
Z-score	-0.0597	0.504***	0.289***
	(0.765)	(0.000)	(0.000)
End of year credit rating	-0.0140	0.0041	-0.0063
	(0.145)	(0.736)	(0.335)
Advertising-to-sales	31.91***	47.64***	28.16***
	(0.000)	(0.000)	(0.000)
Cash-to-sales	0.389	0.233	0.143
	(0.286)	(0.509)	(0.529)
Charter indicator	-0.0458	0.0488	0.0150
	(0.563)	(0.744)	(0.787)
Interest rate hedge indicator	0.0107	0.0077	-0.0237
	(0.840)	(0.909)	(0.537)
Foreign currency hedge indicator	-0.0975	-0.0001	-0.112**
	(0.200)	(0.999)	(0.037)
Fraction of next year's fuel requirements hedged	0.141 (0.605)	0.175 (0.456)	0.172 (0.314)
Fraction of next year's fuel requirements hedged × positive jet fuel hedging gains indicator	0.136 (0.510)	0.0474 (0.826)	0.194 (0.196)
Constant	-0.171	-3.239***	-1.381***
	(0.876)	(0.006)	(0.003)
Observations	120	120	120
R-squared	0.717	0.781	
Number of airlines		14	14

Notes: This table provides the results of the effect that the interaction of jet fuel hedging with gains and losses from jet fuel hedges has on firm value. The dependent variable for each of the three columns is the log of Tobin's Q, the proxy for firm value. All regressions contain year dummies. P-values are in parenthesis. Statistical significance at the 10%, 5%, and 1% levels are denoted by *, **, and ***, respectively.

CHAPTER FIVE:

USING SUCCESSFUL JET FUEL HEDGES TO INCREASE MARKET SHARE

5.1 Investment Opportunities in the Airline Industry

A common problem in the airline industry is underinvestment. This is especially true when the price of jet fuel is high, resulting in low cash flows. Although profitable investment projects may exist, airlines may have insufficient financial capital to undertake them. Froot, Scharfstein, and Stein (1993) suggest that firms hedge to increase cash flows during these low cash flow states in order to fund investments they would not be able to undertake otherwise. As explained in chapter one, airlines commonly hedge the price of jet fuel jet fuel prices are highly volatile and jet fuel expenses make up a large percentage of an airline's operating costs.

Carter, Rogers, and Simkins (2006) investigate jet fuel hedging by airlines to determine if it increases the value of the firm (which they call the "hedging premium"). They find that a large portion of the hedging premium comes from capital expenditures. However, they do not discuss any of the specific investments that airlines undertake to increase value as a result of jet fuel hedging. In chapter 4, using a more recent and larger sample of years, jet fuel hedging only has a positive effect on firm value through capital expenditures when lease adjustments are considered.[25] Leasing aircraft may play an important role in the investment projects that airlines fund through hedging.

5.1.1 Investment Project Classifications

When leasing or purchasing aircraft, airlines must decide how they will be allocated. Airlines typically employ capital budgeting techniques to determine the most profitable uses for their aircraft. Vasigh, Fleming, and Humphreys (2014) describe the two most common classifications of investment projects that airlines can undertake: (1) replacement versus expansion decisions and (2) independent projects versus mutually exclusive projects. In the first classification, newly acquired aircraft can be used to replace older aircraft or can be utilized to expand into new markets. If an airline believes that jet fuel prices will increase in the future, replacing older planes with newer, more fuel-efficient models may be the more profitable option. Additional profits can be obtained by entering into new markets or increasing capacity in markets they already serve.

In the second classification, investment projects can be mutually exclusive or independent. Although many profitable projects may exist, the airline may not be able to fund all the projects at the same time. For example, if an airline has a choice between two profitable projects but only has enough financial capital available at the time to fund one of them, the two projects are categorized as "mutually exclusive." "Independent projects," however, can be funded regardless of the funding status of other available projects. For example, if an airline has enough financial capital available to fund two projects simultaneously, these projects would be

[25] Operating leases (which airlines commonly employ) do not appear on airlines' balance sheets. Adding the value of operating leases to capital expenditures is necessary to provide an accurate measure of an airline's overall investment.

considered independent. Although financially constrained airlines can alleviate the underinvestment problem with hedging, they may find that any additional projects it wishes to pursue using the additional cash flows from hedging are likely to be mutually exclusive. These investment projects must be chosen carefully so that the most profitable one is selected.

Using capital budgeting techniques to make the most profitable investment decisions rests on the assumption that the managers charged with making these determinations are acting in a profit-maximizing fashion for the airline. However, when corporate controls are weak, managers may choose instead to make investment decisions that increase their own personal utility, oftentimes at the expense of the firm. The following section explains how hedging can further exacerbate agency issues.

5.1.2 Principal-agent Problems, Buying Market Share, and Hedging

A section of the hedging literature discusses principal-agent problems that can arise when firms hire managers to make hedging decisions. Smith and Stulz (1985) argue that managers may choose a hedging portfolio that maximizes their own utility at the expense of increasing shareholder wealth. This generally occurs when managerial compensation incentives do not align with the firm objective of profit maximization. For example, if the manager's compensation package includes more stock options, then the manager may choose to hedge less so that the firm's value (as reflected by the firm's stock price) has higher variability. This improves the probability that the manager's stock options can be exercised profitably.

Tufano (1998) identifies a second possible agency issue in which managers use the increased cash flows from hedging on investment projects that increase personal utility but are value destroying to the firm. Financing investment using funds internal to the firm is generally preferable to seeking funding through capital markets because potential lenders are more likely to decline financing to projects they believe will be unprofitable. If the firm has insufficient internal funds to finance its investments, managers may turn to hedging to increase internal funds and avoid the increased scrutiny of outside lenders. Without the input of capital markets, managers are more likely to invest in projects that benefit themselves but make shareholders worse off.

Hedging may also exacerbate the agency problem between a manager's desire to maximize personal utility and the firm objective of maximizing shareholder wealth. The first two cases described previously assume managers are acting in their own interest at the expense of shareholders. However, agency issues may also arise when managers have a misunderstanding of the objectives a firm should pursue or what constitutes profit-maximizing behavior. Hedging can make pursuing these objectives more attractive to managers, especially when the firm has a run of success with its hedges.

A common misconception that can arise among firms, explained in detail by Thomas and Kamp (2006), is the belief that increasing market share is a way to achieve greater profitability or that acquiring higher market share is the primary goal of the firm, even if profits suffer. One possible way to achieve increases in market share is for managers to price their goods and services below the profit-maximizing price, a pricing strategy called "buying market share." If the short-term losses from lowering price cannot be recouped in a later time period, then this pricing strategy will reduce the value of the firm. This strategy raises the question of possible predatory pricing since both require the lowering of price its profit-maximizing level.[26]

[26] Predatory pricing is a pricing strategy where firms lower their price below cost with the purpose of driving rivals out of the market, then attempt to recoup losses by raising price above cost after they exit. This is only successful if barriers to entry are sufficiently high so that other firms cannot enter (or reenter) once predatory firm raises its price.

However, predatory pricing requires a high likelihood that short-run losses can be recouped but buying market share does not.

Managers who engage in buying market share may also have the decision to do so reinforced by an increase in their personal utility, especially if managers' compensation is tied to the relative market shares of the firms. As the market share of the firm increases, so will the compensation that is received by the manager, even as the profits of the firm fall. Creating compensation packages for managers that encourage buying market share behavior can lead to reduced shareholder wealth.

Hedging may influence a manager's decision to buy market share. When hedging is successful, the increased cash flow can be "invested" by lowering the price of the goods or services sold to consumers, in effect buying market share the firm would not be able to attain without hedging. For example, if an airline has successful jet fuel hedges, managers may mistakenly believe that the cost of using jet fuel has decreased. This is not the case, as explained in chapter one, because the cost of using jet fuel is not the price paid for it, but the price that the airline could receive by selling it on the open market. Although costs have not changed as a result of hedging, managers may still attempt to pass on the "savings" to consumers in the form of lower fares which can increase market share. This pricing strategy is likely not profit maximizing as the airline is pricing below its profit-maximizing level, even if it mistakenly does not believe that it is.

5.2 Changes in Market Share and Jet Fuel Hedging Gains and Losses

It follows from the proceeding discussion that successful jet fuel hedging by airlines may be used to buy market share. However, there has been no empirical study on this question to date. It is useful to first determine the association between positive gains from jet fuel hedges and changes in market share. If jet fuel hedging success leads to buying market share, then a positive relationship between realized gains and losses from jet fuel hedging and changes in market share is expected.

It is important to note, however, that finding a positive relationship between realized gains and losses and jet fuel hedging is not sufficient to indicate that buying market share is taking place. An increase in market share may also appear when an airline enters a new market, that is, the market share of the airline increases from zero to a positive number. Care must be taken to account for this possibility when analyzing the data.

5.2.1 Airline Selection, Realized Gains and Losses, and Time Frame

The sample of airlines used in to calculate the market shares used in this chapter are taken from major carriers that hedge a significant portion of their jet fuel requirements. Typically, smaller low-cost carriers use other forms of jet fuel risk management such as fuel pass-through agreements or charter operations that pass on the cost of fuel to other parties. Smaller carriers are much less likely to engage in any kind of buying market share pricing scheme since they would be unable to handle the initial loss of profits that would result. Smaller carriers also tend to leave the larger airlines to compete amongst themselves.

Figure 5.1 shows the realized gains and losses from jet fuel hedging for the sample airlines. Because hedging data were unreliable prior to the passage of FAS 133 in 2001, the analysis begins in 2000 and ends in 2013. The time-series for hedging data are cut short for some airlines due to mergers between major carriers. Northwest Airlines, for example, merged with Delta Air Lines in 2008, followed by a merger of Continental Airlines and United Airlines in 2010, and US Airways and American Airlines in 2013.

Southwest Airlines gained notoriety for undertaking a series of highly successful jet fuel hedges from 2004 to 2008. This allowed Southwest to gain significant cash flows from its hedges that could be used to expand operations to new markets or pass on savings to consumers in the form of lower fares. The analyses of the chapter focus heavily on Southwest Airlines with other airlines considered as robustness checks.

Figure 5.1 shows that, prior to 2009, airlines generally recorded positive gains from their jet fuel hedging activities. However, when the financial crisis reached its peak in 2009, oil prices decreased significantly along with jet fuel prices. All hedging airlines suffered losses of varying degrees. While United Airlines and Delta Air Lines returned to positive jet fuel hedging gains quickly, Southwest continued to sustain jet fuel hedging losses until 2014. The time frame of the analyses is broken into two time periods: (1) 2000-2008, and (2) 2009-2013. This corresponds to the years when Southwest Airlines enjoyed jet fuel hedging gains pre-financial crisis but suffered hedging losses post-financial crisis.

5.2.2 Market Definitions

Episodes of buying market share do not necessarily have to be nationwide, and so it is important to break down an airline's operations into smaller markets. The definition of a market used in this study is taken from the Federal Aviation Administration's (FAA) definition of a city-pair market. The FAA describes a city pair as a city of origin and a corresponding destination city for flights to and from major metropolitan areas ("City Pairs," 2018). For example, a flight from

Tampa, Florida to Phoenix, Arizona and a separate flight from Phoenix, Arizona to Tampa, Florida would be in a single market.

As a robustness check, a narrower definition of a market is considered in this study. The narrowest definition of a market would consider flights to and from distinct airports as separate and unique markets. Furthermore, since some of the larger city-pair markets are served by multiple airports, this study defines each route combination between two *airports* as separate markets, even when the airports operate within the same city market.[27]

5.2.3 Measuring Changes in Market Share

An airline's market share for a given market is determined by the fraction of passengers it flies in the market yearly relative to the total number of passengers flown in the market yearly by all airlines in the sample. The changes in market share are measured in four separate ways with each measure of the change in market share being distinguished by the superscripts in equations (1)-(4). The first two measures consider the change in market share between the endpoints of each time period, 2000 and 2008 in the first time period, and 2009 and 2013 in the second time period. The first measure of the change in market share, S^1, is the *absolute* change in market share between the endpoints for each time period, defined as follows.

$$S^1_{i,1} = s_{i,2008} - s_{i,2000} \tag{1a}$$

$$S^1_{i,2} = s_{i,2013} - s_{i,2008} \tag{1b}$$

[27] For example, Dallas Love Field (DAL) and Dallas/Fort Worth International Airport (DFW) serve the same market and form a city-pair market with Louisville, Kentucky which is solely served by Louisville International Airport (SDF). Using the narrowest definition of a market, the route combinations between these airports would form four separate markets (DAL to SDF, DFW to SDF, SDF to DAL, and SDF to DFW).

where $S^1_{i,1}$ and $S^1_{i,2}$ are the absolute changes in market share in market *i* for time periods 1 and 2, respectively, and $s_{i,t}$ is the market share in market *i* in year *t*, with *t* being the years of the endpoints for each of the time periods 1 and 2. The second measure of the change in market share, S^2, is the *proportional* change in market share between the endpoints for each time period, with expressions shown below.

$$S^2_{i,1} = \frac{s_{i,2008} - s_{i,2000}}{\left(\frac{s_{i,2008} + s_{i,2000}}{2}\right)} \qquad \text{(2a)}$$

$$S^2_{i,2} = \frac{s_{i,2013} - s_{i,2008}}{\left(\frac{s_{i,2013} + s_{i,2009}}{2}\right)} \qquad \text{(2b)}$$

where $S^2_{i,1}$ and $S^2_{i,1}$ are the proportional changes in market share in market i for time periods 1 and 2, respectively, and $s_{i,t}$ defined above. In equations (2a) and (2b), the denominator of the right-hand side is the average market share between the endpoints of each time period.

These two measures provide a simple look at how market share changes for each airline from the beginning to the end of each time period. However, the disadvantage of calculating the change in market share in these two ways is that is does not give a clear picture on how market share changes between the end points of each time period. The airline may enter or exit a market between end points or other airlines may enter or leave. Mergers between airlines may also occur.

The third and fourth measures of the change in market share, defined by S^3 and S^4, respectively, observe the change in market share from year to year. These measures of the change in market share are calculated using the following equations:

$$S^3_{i,t} = s_{i,t} - s_{i,t-1} \qquad \text{(3)}$$

$$S_{i,t}^{4} = \frac{s_{i,t} - s_{i,t-1}}{\left(\frac{s_{i,t} + s_{i,t-1}}{2}\right)} \quad (4)$$

where $S_{i,t}^{3}$ is the absolute change in market share in market *i* at year *t*, and $S_{i,t}^{4}$ is the proportional change in market share in market *i* at time *t*. $s_{i,t}$ and $s_{i,t-1}$ are the market shares in market *i* at times *t* and *t-1*, respectively. In these measures of the change in market share, the years 2000 and 2009 are excluded because each is the first year of their respective time periods. In equation (4), the denominator of the right-hand side is the average market share between year *t* and year *t-1*.

5.2.4 Model for Changes in Market Share and Hedging Gains and Losses

The base model for the analyses is a simple regression model between the change in market share and an indicator variable for jet fuel hedging gains and losses. The indicator variable for hedging gains and losses is formally defined below.

$$H_t = \begin{cases} 1, & jet\ fuel\ hedging\ gains/losses > 0 \\ 0, & jet\ fuel\ hedging\ gains/losses \leq 0 \end{cases} \quad (5)$$

H_t is 1 when an airline experiences gains in its jet fuel hedging activities in year *t* and 0 when it has zero gains or losses or suffers losses from its jet fuel hedges in year *t*. The relationship between changes in market share and jet fuel hedging is determined by the following model:

$$S_{it} = \beta_0 + \beta_1 H_t + u \quad (6)$$

where S_{it} is the change in market share in market *i* at time *t*, H_t is the jet fuel hedging gain or loss indicator at time *t*, and *u* is the idiosyncratic error term.

The model is run separately for each individual airline. The model is also run for each measure of market share described in section 5.2.3. Moreover, restrictions are placed on which markets are included in the sample. Individual airlines do not fly passengers in every available market, nor do airlines fly passengers every year in a market (i.e., airlines commonly enter and exit markets over time). Restricting the sample eliminates markets that are very small or not relevant to an airline's operations. Specific restrictions on the market samples used in the model are discussed in the next section.

5.2.5 Restrictions on the Market Sample

The restrictions imposed on the sample of markets depends on the change in market share measures used in the model. For the change in market share measures in equations (1a), (1b), (2a) and (2b), the market sample is restricted by the number of time periods in which an airline flies a positive number of passengers at the beginning or end year of the time period. Each market only has two observations: the first observation is the change in market share in the 2000 and 2008 time period, and the second observation is the change in market share in the 2009 and 2013 time period. Therefore, each market will fall under one of three possible cases.

1. Case 1: An airline flies a positive number of passengers in none of the time periods. This means that $s_{i,2000} = 0$ and $s_{i,2008} = 0$, and $s_{i,2009} = 0$ and $s_{i,2013} = 0$.
2. Case 2: An airline flies a positive number of passengers at some point in one of the time periods. That is, $s_{i,2000} > 0$ or $s_{i,2008} > 0$, and no passengers are flown in 2009 and 2013, or there are no passengers flown in 2000 and 2008, and $s_{i,2009} > 0$ or $s_{i,2013} > 0$.
3. Case 3: An airline flies a positive number of passengers at some point in two time periods. This requires that $s_{i,2000} > 0$ or $s_{i,2008} > 0$, and $s_{i,2009} > 0$ or $s_{i,2013} > 0$.

The possible restrictions on the market sample using these cases are defined by R_K, where K is the minimum number of time periods where the airline flies a positive number of passengers. Letting k_i be number of time periods where the airline flies a positive number of passengers in market i, restriction R_K is defined as follows: keep any market i that satisfies the following condition.

$$k_i \geq K \tag{7}$$

For example, the R_1 restriction requires that all markets fall under case 1 or case 2 described above. R_2 represents the most restrictive sample where only the markets that fall under case 3 are kept in the sample. R_0 defines the sample of markets with no restrictions.

For the year-to-year changes in market share described in equations (3) and (4), market restrictions are based on the number of years in which an airline has zero market share in market i. These restrictions are defined as Z_M, where M is the minimum number of years in which an airline's market share is zero in a market. If m_i is the number of years that an airline operates in market i, then restriction Z_M is defined as follows: keep any market i that satisfies the following condition.

$$m_i \geq M \tag{8}$$

For example, Z_6 restricts the market sample to markets in which the airline operates for at least six years (markets where the airline operates for 5 years or fewer are dropped). The broadest restriction, Z_{14}, describes a market sample in which an airline operates in each market for every year in the both time periods. Z_0 defines an unrestricted market sample.

5.3 Analysis of Market Sample and Estimation Results for Southwest Airlines

The primary airline considered in the model is Southwest Airlines because of its significant jet fuel hedging gains from 2000 to 2008 followed by is jet fuel hedging losses from 2009 to 2013. First, a discussion of the change in market share statistics for Southwest Airlines is provided. Emphasis is given to how the number of markets is affected by each sample restriction. The mean changes in market share across each time period are compared for each measure of market share. Second, the model runs of equation (6) using each of the market share measures and relevant sample restrictions are analyzed. All results of the model are estimated using ordinary least squares (OLS). Third, robustness checks are performed by narrowing the market definition to individual airports and running the model for other major airlines. Similar to Southwest, some airlines, such as American Airlines, hedge significant portions of their jet fuel requirements. Others, such as Alaska Airlines and JetBlue hedge less of their jet fuel requirements but still record gains and losses from those hedges.

5.3.1 Market Sample and Sample Restrictions

Table 5.1 displays the number of observations, number of markets, and the change in the number of markets for each sample restriction for Southwest Airlines. The total number of markets in the unrestricted sample is 9,465. Removing markets in which Southwest does not fly any passengers in at least one year of the sample time period reduces the sample to 2,750. Restricting the sample to markets in which Southwest flies passengers over at least half of the sample time period (restriction Z_7) reduces the sample further to 1,348. The most restrictive sample, only 591 markets are present. Markets where passengers are more consistently flown from year to year are less likely to influence change in market share through entry or exit. A positive effect of jet fuel hedging on market share in these markets can more reasonably be attributed to airlines investing additional capital (e.g., more aircraft) or buying market share.

Table 5.2 shows the average changes in market share over the two time periods for each measure of market share and relevant restrictions. For the least restrictive samples, the average market share is generally larger during the jet fuel hedging losses period than the hedging gains period. As the sample becomes more restrictive, however, the average change in market share quickly becomes larger during the period with hedging gains. The model is expected to return a positive correlation between the jet fuel hedging gains indicator and the change in market share for more restrictive samples.

5.3.2 Estimation Results

Table 5.3 shows the estimation results for the first two change in market share measures described in equations (1a)-(1b) and equations (2a)-(2b). For each of these measures, the model is estimated three times: once without any sample restriction (R_0), all markets where Southwest Airlines flies passengers in at least one time period (R_1), and all markets where Southwest flies passengers in both time periods (R_2).

The estimate for the successful jet fuel hedging indicator on the change in market share is slightly negative in the unrestricted sample, highly negative in the R_1 sample, but even more strongly highly positive in the most restrictive sample in which Southwest Airlines operates at some point in each time period. All three estimates are highly significant. The highly negative result of the R_1 sample may be explained by markets where Southwest exits a market after year 2000 but never reenters for the remainder of the time period. This is likely because the number of markets in the R_1 sample must overlap with markets that are also in the Z_1 sample (which includes markets where Southwest only flies passengers in one or fewer years of the sample time period).[28]

The positive coefficient on the jet fuel hedging indicator in the R_2 sample may be explained in two ways. First, Southwest may enter markets after 2000 up to 2008 resulting in a large increase in market share between the two endpoints of the time period followed by

[28] The R_1 sample contains 2,496 markets and the Z_2 sample contains 2,042 markets, so 454 markets must come from the Z_1 sample (any markets in the Z_0 sample cannot be contained in the R_1 sample).

marginal changes in market share thereafter. Second, Southwest may be increasing capacity within markets it is already operating in. This can be done by investing further capital resources into a market or making fares more competitive (provided there is competition with other airlines within the market). However, this measure of market share makes these two possibilities impossible to discern from one another because it cannot account for how market share changes between endpoints of the time period.

Year-to-year market share changes better account for entry or exit of an airline or how it changes between years of operation. Table 5.4 shows the estimates for the jet fuel hedging indicator on the change in market share described by equation (3). The hedging indicator coefficient is positive and significant after eliminating markets in which Southwest operates for five or fewer years in the sample time period. The largest coefficient on the hedging indicator is on sample Z_7 and remains above 2.000 between samples Z_6 and Z_9. These market samples correspond to the length of the jet fuel hedging gains time period from 2000 to 2008. Market shares are increasing the most during this time compared to Southwest's hedging losses time frame. Southwest likely entered markets contained in these samples (Z_6 and Z_9) prior to 2008 (provided there was no exit and reentry at a later year), increasing its market share.

The most restrictive market samples, such as Z_{12} and Z_{13}, are of particular interest because market entry is less likely to be the driving force behind these positive jet fuel hedging indicator coefficients. The hedging indicator coefficient for these samples, while not as highly statistically significant as the samples discussed previously, are still significant at standard levels. This suggests that Southwest could indeed be using its successful jet fuel hedges to expand its capacity in markets in which it already operates.

The estimates in Table 5.5 using the year-to-year proportional change in market share measure from equation (4) show much of the same behavior described in Table 5.4. The coefficients show a greater degree of significance across each of the samples. The coefficient in the most restrictive sample, Z_{14}, becomes significant at the 10% level whereas it was highly insignificant using the standard change in market share of equation (3). In markets without the possibility of entry in the sample time period, market share is increasing during periods of jet fuel hedging gains compared to the time period with hedging losses.

5.3.3 Robustness Checks: Airport Markets and Different Airline Model Estimates

The results for Southwest Airlines in the previous section are compared against two separate robustness checks. First, the market definition is narrowed so that routes from one airport to another in a single direction is considered a unique market. Even if an airline flies passengers in a city-pair market, it may not fly routes in both directions to and from each city market, nor may it necessarily operate out of all the airports that serve a city market (provided there are multiple airports serving it). In the narrowed market definition, airports where Southwest does not operate will be removed in the restricted market samples. Changes in the number of passengers flown by other airlines at other airports where Southwest does not fly passengers should not affect the market share of Southwest at the airport in which it does operate.

Second, the model is estimated for other airlines that hedge their jet fuel requirements. None of the other airlines had the level of success that Southwest Airlines experienced hedging jet fuel, even though some airlines did experience moderately significant gains prior to 2009. Three airlines are analyzed with the change in market share model from equation (6): American Airlines, Alaska Airlines, and JetBlue Airways. These airlines are chosen because they operate within the entire sample time frame and are not a part of major mergers during the middle of the time frame.[29]

5.3.3.1 Estimates Using Alternative Market Definition

In this section, the model is estimated using the narrower, one-way airport-to-airport definition of a market. Table 5.6 displays this model estimate for the jet fuel hedging indicator on the change in market share measure from equation (4) for Southwest Airlines. Using this narrower definition of a market, the number of markets in the unrestricted sample more than doubles to 22,506 (from 9,465 markets using the broad market definition). The number of markets remains approximately double for each sample restriction.

The estimation results for the narrow airport definition of a market show similar behavior to the estimates using the broad market definition. The coefficients are mostly positive and highly significant, with the largest coefficient in the Z_7 restriction sample (slightly higher than the Z_7 coefficient from Table 5.5). The most restrictive sample has a highly significant hedging indicator coefficient. At the airport level, the increase in market share during the years of successful jet fuel hedging by Southwest Airlines remains.

5.3.3.2 Model Estimates for Other Airlines

The change in market share model is run for three other airlines: American Airlines, Alaska Airlines, and JetBlue Airways. Each of the model runs uses the proportional change in market share measure from equation (4). All estimates use the broad city-pair market definition used in the primary analyses.

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[29] American Airlines officially merged with US Airways on December 9, 2013, the final year of the sample time period. However, the merger would not be reflected in the passenger data until 2015 when the operating certificates for the two airlines were combined.

American airlines posted jet fuel hedging gains from 2000 to 2008 (hedging data for the airline is unavailable for 2005 and 2006) but also had two years of hedging gains in 2010 and 2011, both of which occurred after the financial crisis. Table 5.7 shows the model estimates for American Airlines. Similar to Southwest Airlines, American shows positive and significant coefficients on the jet fuel hedging indicator variable. The largest coefficient, however, appears on restriction sample Z_9 and do not significantly decrease even in the most restricted samples. American Airlines shows a greater change in market share during periods of hedging gains, even when market entry is less likely to drive increases in market share in the more restricted samples.

Table 5.8 and Table 5.9 show the model estimation results for Alaska Airlines and JetBlue Airways, respectively. Both airlines recorded modest gains and losses from their jet fuel hedges. Few of the coefficients show consistent statistical significance across sample restrictions like Southwest and American Airlines. Successful jet fuel hedges have little effect on changes in market share.

5.4 Conclusion

Firms that hedge can use the increased cash flows to undertake investment that they would be unable to fund otherwise. These additional investments may be profitable to the firm, however, agency problems may arise if there is a mismatch between shareholder and manager incentives. Managers may engage in value-destroying projects to increase their personal utility or wealth at the expense of shareholder wealth. One such agency problem is buying market share, in which managers set price below cost to increase the firm's market share, even if they know that this pricing behavior will reduce profits. Input price hedging may exacerbate this problem if managers are convinced that hedging has lowered costs from lower input prices, allowing them to pass on the "savings" to consumers through lower output prices, possibly inadvertently reducing profits.[30]

In this chapter, an econometric model is constructed to establish the correlation between changes in market share of an airline and successful jet fuel hedging. Southwest Airlines is the primary airline tested in the models because of it was significantly more successful in its jet fuel hedging activities compared to other hedging airlines. Estimates of the model show a positive relationship between changes in market share and jet fuel hedging gains and losses across multiple measures of market share, market sample restrictions, and market definitions. This positive correlation is also demonstrated for American Airlines which experienced modest jet fuel hedging gains, but no statistical correlation for Alaska Airlines and JetBlue Airways.

The results in this chapter, despite being positive and statistically significant, only provide preliminary evidence that airlines with successful hedges may be using the increased cash flow to increase market share. Further analysis is required to determine if airlines are possibly engaging in buying market share with successful hedges or investing in capital to expand into new markets. Future models should incorporate controls for ticket fares, mergers between airlines, and market entry.

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[30] Recall that the opportunity cost of using an input is its next highest-valued use. Purchasing an input at a lower price does not change the opportunity cost of the input.

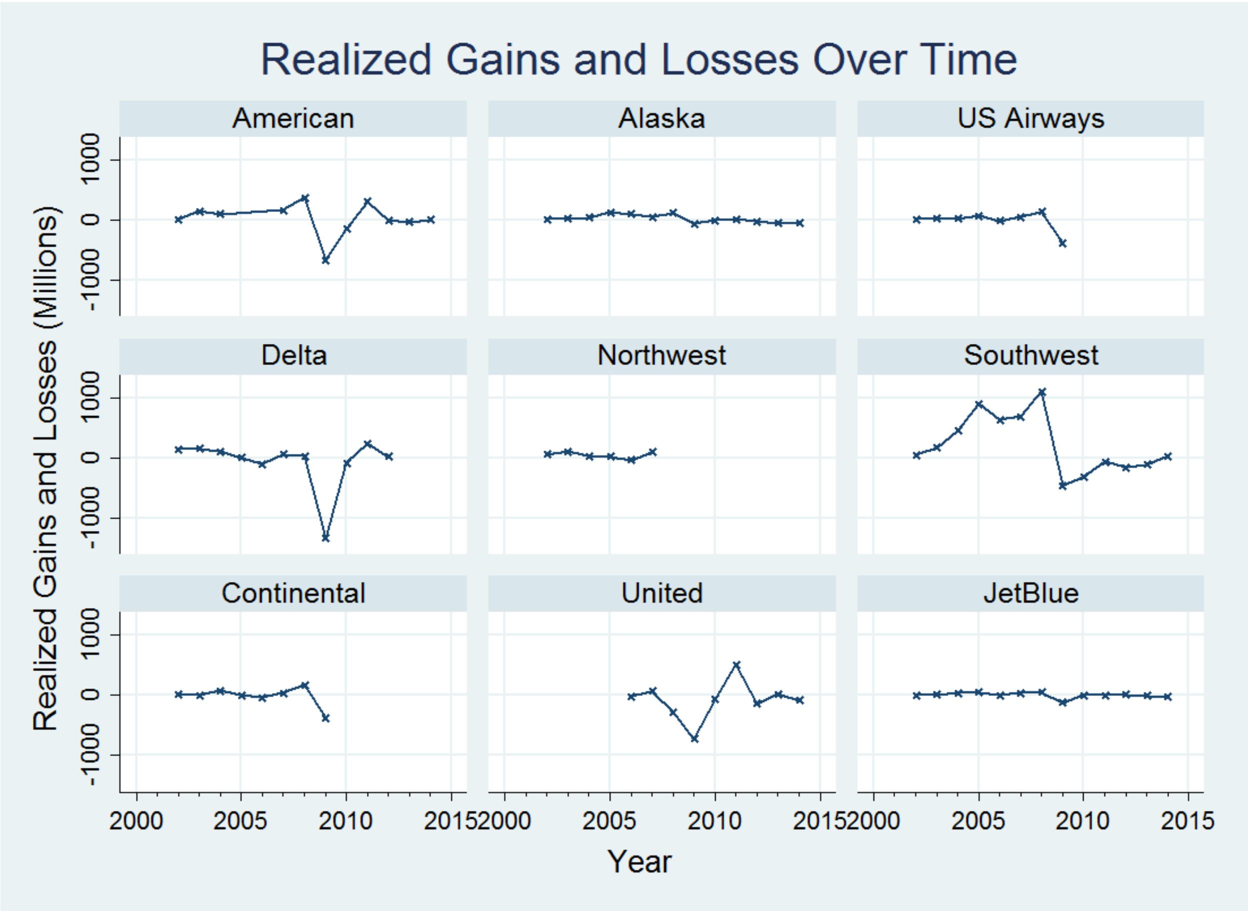

Figure 5.1: Realized Gains and Losses (Millions) from Jet Fuel Hedging for Sample Airlines

Notes: This figure shows the realized gains and losses from sample airlines' jet fuel hedges from 2002 to 2014. Gains and losses data for US Airways, Northwest, and Continental stop prior to 2014 due to mergers with other airlines. Realized gains and losses for United is unreliable prior to 2006 while American Airlines are zero.

Table 5.1: Restrictions on Market Sample Size for Southwest Airlines

Restriction	(1) Observations	(2) # of Markets	(3) Δ # of Markets
S^1 and S^2 Restrictions (R)			
R_0	18,930	9,465	-
R_1	4,992	2,496	6,969
R_2	2,870	1,435	1,061
S^3 and S^4 Restrictions (Z)			
Z_0	113,580	9,465	-
Z_1	33,000	2,750	6,715
Z_2	24,504	2,042	708
Z_3	21,816	1,818	224
Z_4	20,004	1,667	151
Z_5	18,324	1,527	140
Z_6	16,944	1,412	115
Z_7	16,176	1,348	64
Z_8	14,988	1,249	99
Z_9	13,248	1,104	145
Z_{10}	11,916	993	111
Z_{11}	10,692	891	102
Z_{12}	9,588	799	92
Z_{13}	8,448	704	95
Z_{14}	7,092	591	113

Notes: This table shows how the number of observations and the number of markets changes as the market sample becomes more restricted for each of the change in market share measures for Southwest Airlines. Higher numbered subscripts indicate a more restricted sample.

Table 5.2: Average Change in Market Share for Each Sample Restriction for Southwest Airlines

Panel A	(1)	(2)	(3)	(4)
	$\overline{S_{i,t}^1}$		$\overline{S_{i,t}^2}$	
Restriction *R*	2000 and 2008	2009 and 2013	2000 and 2008	2009 and 2013
R_0	5.122	6.990	16.325	19.144
R_1	19.422	26.508	61.906	72.594
R_2	30.786	6.220	101.268	14.312

Panel B	(1)	(2)	(3)	(4)
	$\overline{S_{i,t}^3}$		$\overline{S_{i,t}^4}$	
Restriction *Z*	2001-2008	2010-2013	2001-2008	2010-2013
Z_0	0.640	1.748	2.450	5.033
Z_1	2.203	6.015	8.433	17.323
Z_2	2.861	4.200	11.099	12.434
Z_3	3.099	3.778	12.241	10.096
Z_4	3.318	2.678	13.190	7.718
Z_5	3.524	1.758	14.256	5.075
Z_6	3.638	1.438	15.011	3.707
Z_7	3.538	1.289	14.846	3.286
Z_8	3.396	1.193	14.020	2.858
Z_9	3.021	0.989	12.020	1.972
Z_{10}	2.653	0.954	10.115	2.090
Z_{11}	2.295	0.959	8.321	1.826
Z_{12}	1.770	0.804	6.507	1.328
Z_{13}	1.308	0.656	4.935	0.774
Z_{14}	0.677	0.579	2.613	1.071

Notes: This table presents Southwest Airline's average change in market share for the pre-financial crisis time period (2000-2008) and the post-financial crisis time period (2009-2013) for each sample restriction.

Table 5.3: Southwest Airlines Jet Fuel Hedging on Market Share (Measures 1 and 2)

	(1)	(2)	(3)	(4)	(5)	(6)
Market Share #	1	1	1	2	2	2
Restriction	R_0	R_1	R_2	R_0	R_1	R_2
H_t	-1.869***	-7.086***	24.57***	-2.819***	-10.69***	86.96***
	(0.000)	(0.000)	(0.000)	(0.002)	(0.001)	(0.000)
Constant	6.990***	26.51***	6.220***	19.14***	72.59***	14.31***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Observations	18,930	4,992	2,870	18,930	4,992	2,870
R-squared	0.001	0.006	0.088	0.000	0.002	0.168

Notes: This table displays Southwest Airline's model estimate for the change in market share measures described by equation (1) and equation (2) on the jet fuel hedging indicator variable, H_t, for each sample restriction. P-values are in parenthesis. Statistical significance at the 10%, 5%, and 1% levels are denoted by *, **, and ***, respectively.

Table 5.4: Southwest Airlines Jet Fuel Hedging on Market Share (Measure 3)

Panel A Restriction	(1) Z_0	(2) Z_1	(3) Z_2	(4) Z_3	(5) Z_4	(6) Z_5	(7) Z_6	(8) Z_7
H_t	-1.107***	-3.811***	-1.340***	-0.679	0.640	1.765***	2.201***	2.249***
	(0.000)	(0.000)	(0.002)	(0.125)	(0.144)	(0.000)	(0.000)	(0.000)
Constant	1.748***	6.015***	4.200***	3.778***	2.678***	1.758***	1.438***	1.289***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Observations	113,580	33,000	24,504	21,816	20,004	18,324	16,944	16,176
R-squared	0.001	0.004	0.000	0.000	0.000	0.001	0.001	0.001

Panel B Restriction	(1) Z_8	(2) Z_9	(3) Z_{10}	(4) Z_{11}	(5) Z_{12}	(6) Z_{13}	(7) Z_{14}
H_t	2.203***	2.032***	1.700***	1.336***	0.966**	0.652*	0.0980
	(0.000)	(0.000)	(0.000)	(0.001)	(0.016)	(0.090)	(0.770)
Constant	1.193***	0.989***	0.954***	0.959***	0.804***	0.656**	0.579**
	(0.000)	(0.000)	(0.000)	(0.000)	(0.002)	(0.013)	(0.015)
Observations	14,988	13,248	11,916	10,692	9,588	8,448	7,092
R-squared	0.001	0.001	0.001	0.001	0.000	0.000	0.000

Notes: This table displays Southwest Airline's model estimate for the change in market share measure described by equation (3) on the jet fuel hedging indicator variable, H_t, for each sample restriction. P-values are in parenthesis. Statistical significance at the 10%, 5%, and 1% levels are denoted by *, **, and ***, respectively.

Table 5.5: Southwest Airlines Jet Fuel Hedging on Market Share (Measure 4)

Panel A	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Restriction	Z_0	Z_1	Z_2	Z_3	Z_4	Z_5	Z_6	Z_7
H_t	-2.583***	-8.891***	-1.334	2.144*	5.472***	9.181***	11.30***	11.56***
	(0.000)	(0.000)	(0.226)	(0.060)	(0.000)	(0.000)	(0.000)	(0.000)
Constant	5.033***	17.32***	12.43***	10.10***	7.718***	5.075***	3.707***	3.286***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Observations	113,580	33,000	24,504	21,816	20,004	18,324	16,944	16,176
R-squared	0.001	0.003	0.000	0.000	0.001	0.003	0.004	0.004

Panel B	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Restriction	Z_8	Z_9	Z_{10}	Z_{11}	Z_{12}	Z_{13}	Z_{14}
H_t	11.16***	10.05***	8.024***	6.495***	5.179***	4.160***	1.542*
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.092)
Constant	2.858***	1.972***	2.090***	1.826***	1.328*	0.774	1.071
	(0.000)	(0.005)	(0.003)	(0.008)	(0.051)	(0.269)	(0.101)
Observations	14,988	13,248	11,916	10,692	9,588	8,448	7,092
R-squared	0.004	0.004	0.003	0.002	0.001	0.001	0.000

Notes: This table provides Southwest Airline's model estimate for the change in market share measure described by equation (4) on the jet fuel hedging indicator variable, H_t, for each sample restriction. P-values are in parenthesis. Statistical significance at the 10%, 5%, and 1% levels are denoted by *, **, and ***, respectively.

Table 5.6: Southwest Airlines Jet Fuel Hedging Indicator on Airport Market Share (Measure 4)

Panel A	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Restriction	Z_0	Z_1	Z_2	Z_3	Z_4	Z_5	Z_6	Z_7
H_t	-2.113***	-7.243***	-0.894	2.765***	7.197***	11.16***	13.31***	13.41***
	(0.000)	(0.000)	(0.229)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Constant	4.471***	15.33***	11.26***	8.702***	5.466***	2.485***	1.258**	0.725
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.019)	(0.157)
Observations	270,072	78,768	60,360	53,844	48,108	43,608	39,060	36,084
R-squared	0.001	0.002	0.000	0.000	0.002	0.004	0.006	0.006

Panel B	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Restriction	Z_8	Z_9	Z_{10}	Z_{11}	Z_{12}	Z_{13}	Z_{14}
H_t	12.14***	10.78***	9.040***	6.916***	5.102***	3.506***	1.373***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.009)
Constant	0.421	-0.150	-0.202	-0.269	-0.249	-0.503	-0.456
	(0.399)	(0.759)	(0.677)	(0.567)	(0.572)	(0.210)	(0.229)
Observations	31,524	27,312	23,484	20,760	17,916	15,720	12,900
R-squared	0.005	0.004	0.004	0.002	0.002	0.001	0.000

Notes: This table shows Southwest Airline's model estimate for the change in market share measure described by equation (4) on the jet fuel hedging indicator variable, H_t, for each sample restriction. The market definition in these regressions is at the airport level. P-values are in parenthesis. Statistical significance at the 10%, 5%, and 1% levels are denoted by *, **, and ***, respectively.

Table 5.7: American Airlines Jet Fuel Hedging on Market Share (Measure 4)

Panel A Restriction	(1) Z_0	(2) Z_1	(3) Z_2	(4) Z_3	(5) Z_4	(6) Z_5	(7) Z_6	(8) Z_7
H_t	0.958**	3.524**	6.728***	9.123***	11.84***	13.62***	13.53***	15.50***
	(0.029)	(0.028)	(0.002)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Constant	-1.500***	-5.519***	-9.441***	-11.71***	14.24***	16.25***	16.66***	18.90***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Observations	94,650	25,730	17,900	14,590	12,480	10,660	9,270	8,220
R-squared	0.000	0.000	0.001	0.001	0.002	0.002	0.002	0.003

Panel B Restriction	(1) Z_8	(2) Z_9	(3) Z_{10}	(4) Z_{11}	(5) Z_{12}	(6) Z_{13}	(7) Z_{14}
H_t	15.66***	17.18***	11.57***	11.54***	15.50***	12.94***	11.41***
	(0.000)	(0.000)	(0.002)	(0.002)	(0.000)	(0.001)	(0.002)
Constant	-19.31***	-21.03***	-16.23***	-16.10***	-18.66***	-15.94***	-14.09***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Observations	7,280	6,200	5,320	4,580	3,820	2,890	2,130
R-squared	0.003	0.004	0.002	0.002	0.005	0.005	0.006

Notes: This table reports American Airline's model estimate for the change in market share measure described by equation (4) on the jet fuel hedging indicator variable, H_t, for each sample restriction. P-values are in parenthesis. Statistical significance at the 10%, 5%, and 1% levels are denoted by *, **, and ***, respectively.

Table 5.8: Alaska Airlines Jet Fuel Hedging on Market Share (Measure 4)

Panel A	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Restriction	Z_0	Z_1	Z_2	Z_3	Z_4	Z_5	Z_6	Z_7
H_t	-0.260***	-6.319***	-7.789***	-4.998	-4.124	-6.042*	-4.081	-4.127
	(0.009)	(0.009)	(0.009)	(0.131)	(0.235)	(0.079)	(0.236)	(0.210)
Constant	0.266***	6.474***	7.674***	5.782**	5.031*	6.206**	4.559	4.237
	(0.001)	(0.001)	(0.001)	(0.030)	(0.073)	(0.026)	(0.102)	(0.109)
Observations	113,580	4,668	3,000	2,412	2,028	1,812	1,488	1,344
R-squared	0.000	0.001	0.002	0.001	0.001	0.001	0.001	0.001

Panel B	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Restriction	Z_8	Z_9	Z_{10}	Z_{11}	Z_{12}	Z_{13}	Z_{14}
H_t	-5.682*	-3.575	-2.322	-3.617	-1.175	-4.132*	-2.071**
	(0.092)	(0.283)	(0.478)	(0.156)	(0.611)	(0.053)	(0.022)
Constant	4.927*	3.693	3.076	4.419**	2.968	3.015	1.645*
	(0.076)	(0.183)	(0.266)	(0.041)	(0.129)	(0.125)	(0.050)
Observations	1,260	1,188	1,080	972	912	792	744
R-squared	0.002	0.001	0.000	0.002	0.000	0.006	0.010

Notes: This table presents Alaska Airline's model estimate for the change in market share measure described by equation (4) on the jet fuel hedging indicator variable, H_t, for each sample restriction. P-values are in parenthesis. Statistical significance at the 10%, 5%, and 1% levels are denoted by *, **, and ***, respectively.

Table 5.9: JetBlue Airways Jet Fuel Hedging on Market Share (Measure 4)

Panel A	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Restriction	Z_0	Z_1	Z_2	Z_3	Z_4	Z_5	Z_6	Z_7
H_t	-0.382***	-8.125***	-3.939	-3.917	-3.477	-2.696	-3.227	-6.701
	(0.000)	(0.000)	(0.265)	(0.305)	(0.412)	(0.530)	(0.463)	(0.168)
Constant	0.585***	12.45***	14.31***	16.48***	18.94***	19.14***	20.44***	23.32***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Observations	113,580	5,340	2,256	1,788	1,392	1,272	1,188	984
R-squared	0.000	0.003	0.001	0.001	0.001	0.000	0.000	0.002

Panel B	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Restriction	Z_8	Z_9	Z_{10}	Z_{11}	Z_{12}	Z_{13}	Z_{14}
H_t	-7.365	3.828	4.648	-5.402	-2.869	-21.82***	-12.64*
	(0.141)	(0.484)	(0.425)	(0.427)	(0.679)	(0.008)	(0.081)
Constant	24.05***	16.45***	15.16***	22.35***	20.53***	30.75***	20.83***
	(0.000)	(0.000)	(0.002)	(0.000)	(0.001)	(0.000)	(0.003)
Observations	852	624	552	372	324	216	144
R-squared	0.003	0.001	0.001	0.002	0.001	0.050	0.033

Notes: This table shows JetBlue Airway's model estimate for the change in market share measure described by equation (4) on the jet fuel hedging indicator variable, H_t, for each sample restriction. P-values are in parenthesis. Statistical significance at the 10%, 5%, and 1% levels are denoted by *, **, and ***, respectively.

CHAPTER SIX:

HEDGING LITERATURE CONTRIBUTIONS AND FUTURE REASEARCH

6.1 Summary of Dissertation Findings

In the introduction to this dissertation, two contributions to the hedging literature are emphasized. First, the contribution of the hedging gains and losses variable is discussed in relation to the seminal Carter, Rogers, and Simkins (2006) study. Smaller contributions in the reproduction of empirical findings are discussed as well. Second, the contributions to the anti-trust literature and principal-agent problems in the hedging literature are assessed.

6.1.1 Contributions from Hedging Gains and Losses and Study Reproduction

While the existing theoretical hedging literature explains *how* hedging can increase value, they do not attempt to explain the mechanisms for *when* hedging can increase value. Smith and Stulz (1985) and Froot, Scharfstein, and Stein (1993) explain how hedging can reduce the variability in taxes, probability of financial distress, or solve underinvestment by increasing cash flows in low cash flow states. However, these theories assume that hedging has an expected value of zero. Hedging can only increase cash flow when hedging contracts are exercised when they have positive value. Firms that consistently hedge unsuccessfully will not be able to gain value from those hedges because they do not produce positive cash flow. Hedging gains and losses are introduced to attempt to explain when hedging will increase firm value and when it will not.

Hedging gains and losses variables are added to the firm value models used by Carter, Rogers, and Simkins (2006) to determine the general effect of jet fuel hedging success on firm value. Although it was hypothesized that jet fuel hedging gains and losses should have a positive relationship with firm value, regression results showed a statistically significant negative correlation. This issue is investigated further by accounting for lease adjustments to important variables and eliminating realized gains and losses outliers from the sample using a standard box plot. The majority of the outliers in the data are in 2009 when all hedging airlines suffered considerable losses from falling jet fuel prices and from Southwest's hedging success from 2004 to 2008. After removing these outliers from the sample, the realized gains and losses coefficient became positive but statistically insignificant.

The reproduction of the Carter, Rogers, and Simkins (2006) produces smaller contributions to the hedging literature. In the literature review chapter, the theoretical hedging literature has two competing financial constraint theories regarding the determinants of hedging. Smith and Stulz (1985) propose that financially constrained firms will hedge more to increase their cash flows in low cash flow states. However, Rampini, Sufi, and Viswanathan (2014) argue the opposite case, that financially constrained firms are less able to hedge, even if they want to, because hedging requires collateral that the constrained firms simply do not possess. Carter, Rogers, and Simkins (2006) find evidence that supports the theory that financially constrained airlines hedge less, although they claim it is inconsistent with existing theory (Rampini, Sufi, and Viswanathan (2014) had not yet been published). The reproduction of the determinants of jet fuel hedging from chapter four offers strong support for the theory that financially constrained firms hedge less, both in the decision to hedge and the amount hedged.

The second minor contribution to the hedging literature is the relationship between capital expenditures, the hedging premium, and aircraft leases. The Carter, Rogers, and Simkins (2006) model results find that capital expenditures positively affect the hedging premium. The results of the replication study from chapter four, however, find a negative and statistically insignificant coefficient. However, using lease-adjust variables for capital expenditures and other similarly affected variables produces both positive and statistically significant coefficients. This suggests that leasing aircraft by airlines plays a significant role in the investments that airlines may fund through hedging.

6.1.2 Contributions to Principal-agent Problems, Antitrust Concerns, and Hedging

In the literature review of chapter two, a primary assumption in the theoretical literature is that the investment projects that firms fund with increased cash flow from hedging produces value for the firm. Tufano (1998), however, suggests that increased cash flow from hedging may result in a principal-agent problem where managers engage in value-destroying projects. If a project exists that would benefit a manager at the expense of shareholders or lenders, the manager may be unable to secure external funding for it. However, hedging may allow the manager to raise sufficient internal funds to finance the project, bypassing outside scrutiny.

One possible agency issue that may arise from hedging is buying market share, first introduced by Thomas and Kamp (2006). They propose that managers may believe their objective is to maximize the market share of the firm, even if their strategy to accomplish this goal is value destroying to the firm. To gain additional market share, the manager may set price below cost. Unfortunately, this pricing behavior may be mistaken for predatory pricing and could subject the firm to costly litigation. Hedging may exacerbate this problem. In chapter one of the dissertation, it is established that hedging does not lower the cost of the input hedged because the opportunity cost of the input is the value of its next best use, not the price at which it was obtained. If managers mistakenly believe that successfully hedging lowers the economic costs to the firm, they may be tempted to pass on the "savings" to consumers in the form of lower prices, resulting in increased market share.

In chapter five, a preliminary model is formed to test the correlation between successful jet fuel hedges and changes in market share in the airline industry. Southwest Airlines is used as the primary airline of interest because of its substantial hedging gains in the early to mid-2000s followed by losses in 2009 to 2013. Placing multiple restrictions on the markets used in the regressions, evidence is found suggesting a positive and statistically significant relationship between successful hedging and increased market share. However, it is emphasized that these results are preliminary. One must be cautious before declaring that these results indicate buying market share. As Thomas and Kamp (2006) warn, antitrust officials should be wary of confusing buying market share behavior with predatory pricing schemes. Predatory pricing, particularly the attempt to charge monopoly prices after the exit of rivals, is considered anti-competitive behavior but buying market share is not.

6.2 Future Research

The regressions and models used in this dissertation are by no means exhaustive, particularly for the relationship between hedging and market share. Additional work is required to distinguish between increases in market share from entry into new markets or increasing capacity in existing markets. Controlling for the number of competitors, changes in prices, mergers, among other concerns is also important. Furthermore, in order to demonstrate that a firm is buying market share, it must be shown that the airline is achieving increased market share while pricing below cost. A significant econometric concern is the endogenous relationship between price and market share. That is, while lowering prices may increase market share, increases in market share may allow firms to raise price. Care must be taken to identify strong instrumental variables to control for endogeneity.

Buying market share is also likely to occur at individual markets rather than across all possible markets where an airline operates. As mentioned in chapter five, the predatory pricing case against American Airlines in 2001 only involved four markets. Testing for buying market share may require identifying markets where it is more likely, possibly where larger airlines are competing with smaller carriers who could not sustain operations in a low-price environment.

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