Essays on Corporate Risk Management

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I certify that any material in this thesis which is not my own work has been identified and that no material has previously been submitted and approved for the award of a degree by this or any other University.

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This thesis is dedicated to:

Celine Alara, my little sunshine, gifted to me at 11:30pm on the 12th of July 2013, who made me experience the greatest feeling of all: being a father. As long as blood is pumping through my veins, I will be there for her, loving her.

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Glossary of Terms and Abbreviations:

Available seat kilometres (ASK): Total number of seats multiplied by kilometres flown.
At the money (ATM): A term used in options trading when the strike price of the option is equal to spot price.
BSM: Black-Scholes-Merton
bbl : Unit of volume for crude oil and petroleum products.
Capital expenditures (CAPEX): Funds used by a company to acquire or upgrade physical assets such as property, industrial buildings or equipment.
CASK: Cost per available seat kilometres is a unitary measure of operating cost in the airline industry.
Effective fuel costs (EFC): Fuel expenses including the effects of hedging
EIA: Energy Information Administration
FASK: Fuel cost per available seat kilometres is a unitary measure of fuel cost in the airline industry
Fuel Cost at Risk (FCaR): The highest amount of effective fuel cost that could be obtained with a statistical degree of confidence
FCASK: Fuel costs per CASK is the proportion of fuel costs in total operating expenses
Forward Rate Agreement (FRA): An over-the-counter contract between parties that determines the rate of interest, or the currency exchange rate, to be paid or received on an obligation beginning at a future start date.
FRSK: Fuel cost per revenue seat kilometres is a unitary measure of fuel cost in the airline industry.
FV: Fair Value
FX: Foreign exchange
GAAP: Generally Accepted Accounting Principles
GBM: Geometric Brownian motion
GLS: Generalized least squares
Hedge Effectiveness (HE): Fuel costs saved scaled by FCaR. It is a measure risk-benefit profile of a derivative instrument.
HV: Historical volatility
IATA: International Airline Transport Association
IFRS: International Financial Reporting Standards
Implied Volatility Function (IVF): Value of volatility of the underlying instruments which when input into an option pricing model matches the true price of the exchange traded options to model priced options

Low cost carriers (LCsC): Airline companies that operate under single fleet, single class of seats operating between less busy and smaller airports. They operate only on the short haul.
Major carriers (MC): Airline companies that depend on hub-and-spoke networks with a dynamic revenue management system where seats are priced differently depending on the class and the availability of the seats, point of sale, time of return, etc. They operate both long haul and short haul using variety of airplanes and main airports.
NYMEX: New York Mercantile Exchange
OLS: Ordinary least squares
Operating expenditures (OPEX): Expenditures business incurs as a result of its operations.
Over the counter (OTC): Derivative instruments traded off-exchange and conducted directly between parties.
Out of money (OTM): A term used in options trading when the strike price of the call (put) option is greater (lower) than the spot price.
Revenue seat kilometres (RSK): Total number of seats purchased multiplied by kilometres flown
Realized volatility (RV): Volatility occurred in the past.
TRY: Turkish lira
USD: U.S. dollar

ABSTRACT

This thesis examines operational and financial implications of jet fuel risk management. The first element of the thesis use global sample of 54 airline companies from 2000 to 2012, resulting in 411 firm-year observations. The results show that hedging strategies are effective at reducing the variability of operating cash flows and capital expenditures. The results also provide evidence that jet fuel hedging is associated with lower fuel expenses as a percentage of operating expenses. Partitioning the sample into the low cost carrier and major carrier business model sub-samples, the study identifies value premium of 5% to 8% of the average total market value associated with hedging for low cost carriers. These results are robust to fixed effects and instrumental variable regressions and empirically support value maximization via hedging when firms have high financial distress costs and significant investment opportunities. Finally it is evidenced that government ownership reduces firm value, capital expenditures, profitability and hedging ratios. However, lower firm values observed for airline companies with government ownership is not associated with their hedging practices. The second element of the thesis conducts two case studies using the fuel consumption data of Turkish Airlines. In one of the case studies a hedging scenario using a spectrum of derivative instruments is compared to a scenario of no hedging. In the other case study a hedging scenario using a spectrum of derivative instruments is compared to the actual hedging program of Turkish Airlines. Results indicate that regardless of the derivative instruments used hedging could have saved hundreds of millions of dollars in fuel bill for Turkish Airlines. Needless to say, having saved millions in fuel costs could have significantly improved operational and financial performance of Turkish Airlines. Moreover, the results indicate that the inclusion of non-linear pay-off derivative instruments to a portfolio of linear pay-off derivative instruments significantly reduce the cash flow exposure of the combined portfolio. The third element of this thesis investigates the term, selective hedging, which is a hedging methodology that incorporates managements' so called market knowledge and expectations. The study aims to add a third dimension, which is the choice of derivative instrument, on the selective hedging argument which is limited to the timing and the magnitude of the hedges. It is acknowledged that the choice of derivative instrument has greater cash flow implications for firms that are dependent on exchange traded derivative instruments with limited and/or no access to over the counter derivatives. These firms generally have insufficient credit rating to be eligible to be counterparty to an arm's length trades. Commodity end-users such as airline companies constitute relatively little proportion of total oil consumption which is around the 4% of the total world consumption (IATA, 2012). As a result, it is natural to expect the management of these firms with limited and/or no access to over the counter derivatives to take into consideration the market sentiment in their hedging decision. Using the implied volatility functions of oil options on futures traded in NYMEX, this study tests whether the implied volatility observed in oil contracts are loaded with useful information about the direction of oil prices and whether an oil risk hedger can benefit from this information, if any. The results show that the implied volatilities observed in oil markets do not provide privileged information about the direction of oil prices, at least for the short end portion of the contracts. These results might be affected by the time series properties of the observations.

1. INTRODUCTION

1.1. Aims and Objectives of the Thesis

Corporate risk management has been one of the most celebrated topics of the corporate finance literature in the last three decades. Although most of the late 1980s and 1990s have been dedicated to understanding the underlying motivations for corporate risk management, academics and practitioners have found themselves in need of rejuvenating our understanding of the importance of managing financial as well as operational risks for most of the 2000s, particularly after the 2007-2008 financial crisis.

The starting point of most of the theoretical work done in corporate risk management refers to the Modigliani and Miller (1958) irrelevance theorem, which laid the foundations of the modern corporate finance. The basic intuition of the theorem is that, under certain assumptions, any gain from using more of a type of financing (debt), which might seem to be cheaper, is offset by the higher cost of the other (equity). Hence, given a fixed amount of total capital, the allocation of capital between debt and equity is irrelevant because the weighted average of the two costs of capital to the firm is the same for all possible combinations of the two.

The relevant argument of the Modigliani and Miller theorem for the purposes of the corporate risk management literature is that under frictionless market assumptions, such as no taxes, no information asymmetry and no transactions costs, investors can identify and hedge their own exposures and do not pay a premium for firm level hedging. Put differently, hedging is irrelevant.

For decades researchers have examined whether and why some firms engage in hedging strategies as well as the financial and operational implications of hedging. Introducing capital market imperfections to the frictionless Modigliani and Miller (1958) world, scholars rationalize hedging with the reduction of the volatility of tax expenses, maximization of tax shields, reduction of firm level risk, alleviation of financial distress costs, reduction of managerial risk aversion and alleviation of underinvestment problems (Smith and Stulz, 1985; Mayers and Smith 1987; Nance, Smith and Stulz, 1993; Tufano, 1996; Stultz, 1996; Froot, Scharfstein and Stein, 1993). Perhaps due to the mixed evidence from the empirical studies for most of the above theory, the corporate risk management literature of the 2000s proposes more direct approaches to determine the benefits of corporate risk management. These studies particularly test whether corporate risk management has direct implications on value and riskiness of companies (Guay 1999; Hentschel and Kothari, 2000; Allayannis and Weston, 2001; Allayannis and Ofek, 2001; Jin and Jorion, 2006; Carter, Rogers and Simkins, 2006).

Two of the most interesting industries to study the value and risk relevance of corporate risk management have been the commodity producers (e.g., oil producers) and commodity end-users (e.g., airlines). Studies that examine the risk relevance of hedging, more precisely the association between hedging and firm level risk reduction, provide mutual evidence that hedging, is indeed, associated with reduced firm level risk for both industries (Jin and Jorion, 2006; Carter, Rogers and Simkins, 2006). However, value implications of hedging yield contrasting evidence for the two industries; positive association between firm value and hedging for the commodity end-users (Carter, Rogers and Simkins, 2006-for the airline industry) and no association between firm value and hedging for the commodity end-users (Jin and Jorion, 2006-Oil and Gas producers; Tufano, 1998-Gold Miners). This contrast in the empirical observations of hedging and firm value is arguably the result of an industry-specific perception of risk. For example, Jin and Jorion (2006) state that their results might be due to the potential that investors might prefer oil and gas stocks to gain exposure to oil and gas prices themselves.

As a result, the first element of this thesis, Hedging and Firm Value, aims to challenge the interesting question; whether hedging is value-relevant or not. Examining the airline industry as an end-user of oil, this study aims to ask industry-related questions in the light of the theoretical models proposed in the literature. In particular, the analysis in the first element aims to exploit a number of arguments that have been overlooked in the literature which can potentially be of economical and statistical significance in the implications of jet fuel price risk management. For example, this study expands upon the Carter et al. (2006) study by splitting the sample into a more up-to-date business model classification that incorporates both low cost carriers (LCCs) and major carriers (MCs). Although the sample choice is homogenous, inherent differences in the two business models, which are economically significant, have not been examined before.

On the other hand, studies in corporate risk management have largely concentrated on the U.S. firms and ignore the developments towards better risk management practices of non-U.S. firms and derivatives markets outside of the U.S. Moreover, the airline industry deregulation is accomplished in 1978 in the U.S. whereas the deregulation has been rather gradual and less efficient outside of the U.S. Hence, a significantly important difference between the U.S. and non-U.S. airline companies is the ownership structure where still a considerable number of non-U.S. airline companies incorporate government ownership. The global airlines data used in this section enable one to investigate cross-regional differences among airline companies which might affect the results of the regressions that are otherwise unobservable.

It is no secret that some airline companies receive implicit and/or explicit government aid, as part of an inefficient deregulation process. The role of government involvement in management, be it implicit or explicit, has not been examined, at least in the context of airline industry risk management practices. The particular question the first element asks whether government ownership is associated with lower propensity to hedge (lower-risk aversion). It could be argued that the differences in hedging behaviour (if any) might be a result of the comfort of having financial support from governments (too big to fail) and/or less efficient risk management policies of these airlines. Hence, the first element of this thesis, from this particular point of view, is not only interesting for the corporate finance and risk management literatures but for the literatures studying corporate governance and airline transportation and management.

The second element of the thesis, “Hedging Effectiveness and Instrument Choice” studies the use of derivative instruments and hedging strategies available for the airline industry with a retrospective case study approach. The literature on corporate risk management sets forth a number of theoretical arguments as to why firms should hedge. However, despite these incentives for hedging, which are discussed in greater detail in the first element of this thesis, not all firms hedge. What's more, although there is an ample literature on the corporate incentives to hedge, there is only one study that evaluates the use of derivative instruments with a case study approach (Gerner and Ronn, 2012). The airline company data Gerner and Ronn (2012) use is not disclosed and the general idea of the study is to compare the case where an airline company hedges using futures (linear pay-off derivative instruments) to the case where an airline company includes options (non-linear pay-off derivative instruments) to their futures portfolio. This study proposes that using options alongside with futures can increase the efficiency (in terms of cash flow generation) of hedging portfolios, or fine-tune them using the precise terminology.

The second element of this thesis, on the other hand, use the data for Turkish Airlines, a company that did not hedge until 2008, and only started hedging insignificant portion of its fuel consumption for 2009 and onwards. It is important to choose an airline company that did not hedge for most of the sample period examined which is from 2005-2011. It will enable this section to compare the actual operational and financial ratios of Turkish Airlines to operational and financial ratios achieved under different hedging scenarios using different derivative instruments. In addition, this section also compares the case where Turkish Airlines not hedging in any of the years (benchmark scenario) to a case where Turkish Airlines hedging in all years using different derivative instruments.

In summary, this section differentiates itself from Gerner and Ronn (2012) in two points. First, it conducts two case studies. In the first case study a simple non-hedging scenario (benchmark scenario) is compared to a hedging scenario where both scenarios use the actual fuel consumption data from Turkish Airlines. This case study evaluates a scenario where Turkish Airlines is assumed to have not hedged in any of the 7 year period examined. In the second case study the actual hedging program of Turkish Airlines (which remained unhedged for the most of the sample period) is compared to a hedging scenario where Turkish Airlines is assumed to have hedged in all of the years. Hence, unlike a case study where a firm is already hedging using linear pay-off futures instead of non-linear pay-off options, this section compares the benefits from hedging to non-hedging. Second, this section is not limited to a single form of non-linear pay-off derivative instrument, such as Asian options, as is used in Gerner and Ronn (2012). Instead it aims to quantify the efficiency of using a spectrum of derivative instruments in a hedging scenario and compare the results to the two alternative cases.

In addition, the analysis also compares each of the hedging instrument with each other in terms of their potential for cash flow generation and volatility reduction, which is referred to as the "hedging efficiency" (HE). This measure is the ratio that estimates whether a spectrum of non-linear pay-off derivative instruments can fine-tune linear pay-off derivative instruments. Fine-tuning in this study, however, is not limited to cash flow generation from the derivatives, as measured in Gerner and Ronn (2012), but also includes the volatility implications.

From the corporate risk management point of view, the second element of the thesis complements the study in the first element. The effectiveness of any hedging program, when taken as a percentage of any given risk exposure being eliminated/altered, is dependent on so many factors other than just a mere quantitative measure. These factors include the sophistication/expertize of the management team or the department in charge of risk management, firms' liquidity position, size (economies of scale), maturity profile of the actual risk exposure and derivative instruments, and the type of derivative instruments used. Some of these factors are testable and should be controlled for when measuring the effectiveness of corporate risk management program. The first element of this thesis controls for some of these factors such as firm size, liquidity. The second element of this thesis focuses on the type of instruments used in oil price risk management. The detailed analysis of the type of instruments as part of a case study reveals the importance of derivative instrument choice in the success of a risk management program.

The derivative instruments used in the second element of this thesis makes certain assumptions about the liquidity position, creditworthiness and the availability of derivative products at market prices with no transaction costs and/or basis risk. The assumptions made in the second element is the common weakness of almost all of the theoretical and empirical work on corporate risk management, due to data limitations of actual hedging transactions. However, it is crucially important to acknowledge that not many of these assumptions can be applicable to all airline companies in practice which is what exactly the third element of this thesis, Corporate Hedging with Futures and Options: The Role of Implied Volatility, aims to do.

In practice, firms that smaller in size (with less pledgeable assets), with lower liquid reserves, greater financial risk are subject to greater scrutiny by trade counterparties when participating in derivative transactions, particularly when these firms lack the required credit rating. These firms are unlikely to obtain over-the-counter (OTC from here on) derivative instruments which can significantly reduce the volatility risk resulting from the mark-to-market features and the basis risk inherent in exchange traded instruments. Bodnar et al. (1998) provides evidence that around 40% of the firms using derivatives insist on a credit rating of AA or better for their counterparty. Recent financial crisis and the bankruptcy of Lehman Brothers have only fostered concerns related to the liquidity positions of the counterparties to the trades. This results in greater collateral requirement and credit position for tailor-made derivative instruments with willing counterparties, particularly for small firms with limited cash or asset position and/or credit rating to secure such deals.

As a result, these firms are left with exchange traded instruments which have mark-to-market features and basis risks that increase the volatility of the entire derivatives portfolio and the overall risk exposure. The third element of this thesis investigates a new approach on the determination of an optimal choice of pay-off structure (linear-futures, and non-linear options) for the risk management programs of these firms (oil price risk management in this case) with limited or no access to OTC derivatives markets. The aim of this section is to use the market sentiment inherent in the implied volatility functions (IVF) of the oil options on futures traded on NYMEX and determine a methodology which would target the minimum cash outlay (in terms of premiums paid etc.) and maximum cash inflows from the transactions. The contributions of the third element of this thesis are twofold. First, this section tests whether implied volatilities are loaded with relevant information with regards to future prices of oil which is important from the financial economics point of view. Next, it aims to bring a practical methodology to determine optimal choice of instruments for firms that use exchange traded derivatives and revolve their positions frequently, which is important from the corporate risk management point of view.

1.2. Hedging and Firm Value

This section revisits the argument of hedging and firm value using a dataset that consists of 54 global, publicly-traded airline companies over a 13-year period from 2000 to 2012. In addition, appendix 3 of the thesis examines a dataset that consists of 60 airline companies and use hedging dummy variables instead of continuous hedging variables. Following Allayannis and Weston (2001), this section takes the direct approach to investigate whether and under what circumstances hedging enhances shareholder value. Examining foreign currency derivatives use in a sample of non-financial U.S. firms between 1990 and 1995 and using Tobin's Q as a measure of firm value, Allayannis and Weston (2001) observe that hedging is associated with a value premium of 4.87%. More recently, Carter et al. (2006), examining the US airline industry, report a jet fuel hedging premium of 5% to 10% for the period between 1992 and 2003.

The airline industry offers an ideal environment to study hedging behaviour for a number of reasons: First, the industry is significantly exposed to the availability and price of oil. Consequently, airline companies extensively use financial instruments to manage fuel prices. System-wide fuel expenses reached $140bn in 2012, the equivalent to one-third of operating expenditures and clearly a major impact on profitability (IATA, 2012).[1] Second, in the majority of the cases airline companies use derivatives only for hedging and not for speculative purposes. Hence, the likelihood of speculation through hedging is very slim. Third, the industry does not benefit from natural hedging. The increased demand for air travel (and the resulting expected increase in revenue) generated by any stimulation in the economy

[1] The International Air Transport Association (IATA) is an international industry trade group of airlines that creates regulation for international air transport.

is shared among the entire industry, whereas increases in oil prices, resulting from the same economic activity, will have a direct and proportionate impact on the fuel expenditure of each and every airline company (in the absence of hedging). Finally, the industry makes extensive use of debt financing. As the level of fixed claims over total assets increase, particularly in a highly competitive low-margins environment such as the airline industry, the probability of experiencing financial distress costs and even default significantly increase (Nance, Smith and Stulz, 1993). Consequently, potential benefits from hedging are expected to be high for the industry.[2]

The first difference of the analysis in this section compared to the Carter et al., (2006) study is that unlike Carter et al., (2006) who classifies airline companies into major carriers and small carriers based on the scale of annual revenue, it uses more up-to date definition of business classification used in the industry, namely low cost carriers (LCCs) and major carriers (MCs). The classification made in Carter et al., (2006) study entails selection bias. Within their sample, the majority of firms regarded as small carriers are actually *regional* carriers. These carriers have a totally different business model to both LCCs and MCs, particularly in two aspects: First of all, these carriers mostly have fixed-fee agreements with major airline contractors. These fees are set to cover the regional carriers' operating costs and to guarantee a pre-determined level of profit. These fixed-fee contract schemes, which have been effectively used since the late 1990s, eliminate all of the risks related to passenger demand and profit margins (Lederman and Januszewski, 2007). More precisely, unlike the higher price elasticity of passenger demand outlined in Carter et al (2006), the size of revenues for regional carriers is, in practice, independent of the number of passengers carried. Secondly, their business model allows them to transfer the majority of the jet fuel price risk to their contractor firms which provide them with the most effective risk management tool available.

Unsurprisingly, these regional carriers hedge almost none of their jet fuel price risks. Indeed, they are the only airline companies that do not hedge in the sample of Carter et al. (2006).

[2] The theory of corporate risk management states that there is little or no benefit from hedging for firms with little or no debt financing. Having virtually zero probability of financial distress risks, these firms can find it easier to access external funding and have more room for increasing debt capacity at lower costs absent hedging. Consequently, hedging is expected to be most beneficial for firms with high financial leverage and inadequate cash balances to service obligatory payments and utilize investment opportunities.

This fact is somewhat acknowledged by the authors with the use of fuel pass-through and charter dummies to control for other means of risk management practices. However, fuel pass-through schemes are not only utilized by regional carriers but are also periodically utilized by major carriers. Additionally, the use of fuel pass-through dummy variables does not adequately capture the magnitude of cash flow volatility (as a result of fuel price fluctuations) transferred from regional carriers to major carriers. Consequently, any analysis examining firm value and hedging with a sample composition that involves regional carriers (which can utilize close to perfect operational hedging strategy by transferring almost all the oil price risk to the parent contractor airline company) alongside major and low cost carriers (that *have to* utilize financial hedging strategies) will produce potential endogeneity bias. Such analysis will effectively become a comparison between financial hedging and operational hedging. As a result, regional carriers are excluded from the sample. Appendix 1 provides further evidence of the fuel price risk management of some of these regional carriers.

LCCs have gained significant operational strength since the beginning of the early 2000s and now hold a large share of operations in the short-haul segment with the plans to extend the business into long haul format (a good example is Air Asia X). As a result the time period examined from 2000 to 2012 can be described as the high growth period for the LCCs and mature/stable growth period for the MCs. The thesis provides evidence supporting this argument in the results section (section 4) and in Figures 9 and 10. It is known that the alleviation of the underinvestment problem is one of the underlying motivations for corporate hedging (Froot, Scharfstein and Stein, 1993). It is also known that the underinvestment problem is potentially more severe for high growth firms (Myers, 1977; Brennan and Schwartz, 1981; Essig, 1991). Coupled with the significant financial leverage used, jet fuel hedging might contribute to firm value maximization if it helps reduce variability in operating cash flows and preserve internally generated cash funds, which in turn alleviates potential underinvestment costs and the probability of experiencing financial distress costs. Thus, the partition of the sample into low cost carrier and major carrier sub-samples enables one to control, and test for, the association between hedging and potential underinvestment problems within the two different business models; one in a high-growth state and the other in its mature state-while holding the industry constant.

The partition of the sample into LCC and MC sub-samples also controls for potential bias towards one of the business models that might otherwise affect the hedging decision. For example, MCs, in their more established stage might hedge less compared to LCCs in their growth stage. A greater level of hedging might coincide with higher firm value for LCCs which would bias regression coefficients upwards, increasing the likelihood of endogeneity.

Another contribution of the study is to expand analysis to a global level, which is currently limited to the U.S. firms. This will enable to control for cross regional differences among airline companies, which can be important in several aspects. First of all, examining a global sample allows one to capture the differences between deregulated markets like the U.S. and Europe and the rest of the world. Accordingly, the effects of government ownership on risk management practices in the industry are controlled. Government ownership is observed in non-U.S. airline companies and is particularly prevalent in the international sample. Airline companies with government ownership of 20% or above of their total shares outstanding are herein identified as government-owned airline companies.

This study differentiates itself from the existing literature by taking a two-step approach in testing the implications of corporate hedging. The single most important underlying motivation for corporate risk management is the elimination of the undesirable volatility risk inherent in future operating cash flows (Smith and Stulz, 1985; Froot et al., 1993; Nance, Smith and Smithson, 1993). Empirical studies that examine the value premium associated with corporate hedging often disregard the core principle of cash flow volatility reduction via hedging. As an example, none of the studies analysing corporate hedging and firm value in commodity price risk management tests whether hedging is useful in terms of reducing variability in operating cash flows.

After establishing operational gains from jet fuel hedging (if any) the next question this section aims to answer is; why would one expect well-diversified investors to pay premium for firms that hedge? Despite having minimal exposure to idiosyncratic risks, even well-diversified investors will become concerned when the magnitude of financial risks becomes such that the volatility in the operating cash flows significantly increases the probability of financial distress or even default (Stulz, 1996). High leverage and low profit margins expose airlines to significant financial distress costs and might urge investors to be particularly cognizant of the importance of the risk management.

On the other hand, if investors can easily identify and hedge their own risk exposures, why would they ever need firm level hedging? Despite the rationale behind in-house risk management argument, quantifying the risk exposure might not be as straightforward when there are information asymmetries.[3] The ability to measure and hedge firm-specific risks might be limited by the quantity and/or quality of financial disclosure. Information on the level of exposure to a specific risk factor is harder to obtain for companies in emerging markets in comparison to companies in established markets. For example, in the case of a U.S. airline company, a U.S. investor may calculate the approximate risk exposure to oil prices. The information related to a period of fuel consumption is readily (and *mandatorily*) available for these companies. However, the same information is only voluntarily disclosed for non-U.S. firms. In fact, for a U.S. airline company, an investor faces a single dimensional risk of oil prices that are traded in the same functional currency of a U.S. airline company.

For a non-U.S. airline company, however, the risks related to oil prices also have a U.S. dollar exchange rate dimension which makes the overall risk exposure harder to quantify. A non-U.S. airline company that hedges a certain portion of its U.S. dollar fuel expenditure might prefer to net-out some of the currency risks related to the hedged portion of oil price exposure using its receivables. This might function as an effective means of operational hedge but the information related to the extent of such a strategy is likely to be company specific. As a result, investors left with the information asymmetry might over or under hedge the actual exposure.

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[3] The asymmetry of information problem between management and shareholders is discussed by Myers and Majluf (1984); Krishnaswami and Subramaniam (1999); Healy and Palepu (2001) among many others.

Given these information asymmetries and the significant probability of experiencing financial distress costs, investors might prefer airline companies that acknowledge and implement operational and/or financial hedging strategies against these risk factors. Hedging might contribute to firm value maximization if it reduces cash flow volatility and preserves internally generated cash funds which help reduce potential underinvestment problems and the probability of financial distress. Thus, the second stage of the analysis examines the proposition of shareholder value maximization via hedging.

As is the case for any empirical corporate finance research, the results of this study might be subject to potential endogeneity-related problems. Some of the firm-specific factors, such as government ownership, differences in business models and operating regions, are observable variables that are controlled for to prevent any potential endogeneity-related bias.

Most importantly, the test variable, the percentage level of next year's fuel consumption hedged, is determined by the management of the company. In the decision making process, the management might be influenced by factors which are unobservable such as the ability to transfer the portion of fuel costs on to customers (fuel surcharges), managerial expectations about future cash flows, and managerial risk aversion.[4] All these unobservable factors subject the results of the analysis to potential omitted variable bias. This potential omitted variable bias is tackled in section 4.2.2 using first differenced analysis, fixed effects models and instrumental variable regressions.

Instrumental variable regression includes variables which are correlated with the hedging decision and are expected to influence the independent variable (log of Tobin's Q) only through its association with hedging. The literature on corporate hedging suggests potential variables that could be suitable as instrumental variables. The first instrumental variable used is the availability of managerial stock options. As suggested by Smith and Stulz (1985), when management cannot diversify their personal wealth away from firm-specific factors, that is when a large portion of the management's wealth is tied to the firm value, management is more likely to hedge those risks. Managers with stock options, however, are provided with

[4] Fuel surcharge data is available for the U.S airline companies but only voluntarily disclosed outside of the U.S.

greater financial flexibility and might be less risk averse. These arguments are empirically supported by Tufano (1996).

The next instrumental variable is the one year ahead expected oil prices obtained from the "Annual Energy Outlook" published by the U.S. Energy Information Administration (EIA). The empirical evidence on corporate hedging suggests that managers input their personal view on future prices and this in turn affects their hedging decision. This is called "selective hedging" and is supported by Adam (2003), Brown, Crabb and Haushalter (2005) and Faulkender (2005) among others.

The third instrument used is the ratio of off-balance sheet leases to total assets. The use of off-balance sheet leases is common in the airline industry and is a proxy for the level of investment opportunities. The underinvestment framework suggested by Froot et al. (1993) argues that under costly external financing firms aim to align the maturity mismatch between internal cash flows and investment spending. Hedging is beneficial to the extent that it protects internal cash margins. Parallel to the underinvestment theory, firms with a higher ratio of off-balance sheet leases as a percentage of total assets (greater investment opportunities) are more likely to hedge their jet fuel exposures compared to firms with a lower ratio.

The fourth and final instrument used is the proportion of rival airline companies hedging with respect to the total number of rival airline companies. The identification of rival airline companies is limited to airlines operating in the same region because the information regarding routes is largely company specific. In line with Nain (2004), it is expected that firms have a higher propensity to hedge their jet fuel exposures if the proportion of their competitor airline companies hedge. The results suggesting a positive association between hedging and firm value for the low cost carrier sub-sample are robust to these control variables and analyses.

1.3. Hedging Effectiveness and Derivative Instrument Choice

The second element studies the use of derivative instruments and hedging strategies available for the airline industry with a retrospective case study approach. Every company is exposed to two types of risks: 1) business risk and 2) systematic (market) risks. Companies are established to gather expertise and a tacit knowledge of business risks in order to (ideally) manage these risks better than investors. Consequently, management expertise is a big part of the sustainable competitive advantage of the company. However, it is often at management's discretion whether to take on an extra amount of cash flow risk as a result of systematic risks which are, to some extent, manageable using financial instruments. Corporate hedging theory is based on the alteration of the magnitude of these manageable (hedgeable) risk factors to acceptable levels.

The basic tenet of corporate risk management is the reduction in the variability in cash flows and, therefore, firm value (Smith and Stulz, 1985). Accordingly, numerous papers examine whether increased cash flow volatility is associated with higher firm value. Minton and Schrand (1999), examining 1000 non-financial firms from 1988 to 1995, state the negative association between cash flow volatility and investment expenditures (capital, R&D and advertisement expenditures). Similarly, Shin and Stulz (2000), Allayannis and Weston (2003), document the negative association between cash flow volatility and shareholder wealth.

On the other hand, there is a substantial amount of research which asserts that stock prices do reflect the price risks associated with firm-level risk exposures: Jorion (1990), Bartov, Bodnar and Kaul (1996), Allayannis and Ihrig (2001), Pantzalis, Simkins and Laux (2001) among many others. Additionally, the following studies support the notion that hedging is associated with lower levels of risks: Tufano (1998), Guay (1999), Allayannis and Ofek (2001), Jin and Jorion (2006). In contrast, Hentschel and Kothari (2000) find no relation between the volatility of a firm's stock prices and the size of the firm's derivative positions. They argue that many of the firms with sizeable derivatives positions display similar risk characteristics to the risk characteristics of firms with no derivatives use.

One of the main theoretical premises behind corporate hedging is “variance minimization”. Over time however, the variance minimization approach has become less popular among theorists and empiricists. Instead a more effective approach which propounds the view of firm value maximization is suggested (Stulz, 1996; Copeland and Copeland, 1999). Stulz (1996) argues that the theory of variance minimization via hedging is not consistent with the practical applications of hedging strategies by companies. He argues that a better risk management policy should enable the firm to take advantage of upside potential but also protect the firm against a reduction in cash flows to critical levels, termed “hedging the tail risk”. Copeland and Copeland (1999) argue that the minimization of the variance of the hedged operating cash flows is an insufficient condition for minimizing the probability of business disruption (financial distress).

Based on the above discussion, more recent corporate hedging theory still supports the view that corporate risk management strategies are not aimed at producing consistent positive cash flows and increasing expected returns. These would otherwise be called “speculative motives” rather than risk management. Consequently, the benefits of hedging are expected to be accrued by the firm through the alleviation of the market imperfections mentioned in the first element of this thesis. However, it also accepts the practical applications of corporate hedging in which some companies are confident enough to input their own market view in their hedging decisions. The managers of these companies might have insider information or unique knowledge of their own industry. This tendency of exploiting the so-called information advantage is called “selective hedging” (Stulz, 1996).

Selective hedging is usually referred to as market timing in the finance. Stulz (1996) argues that it is acceptable for a firm with little or no financial leverage, and hence the probability of experiencing financial distress, to hedge selectively based on its informative advantage (also called comparative advantage). These firms are better able to withstand unexpected adverse movements in prices compared to financially levered firms.

The phenomenon of the existence of "selective hedging" has received strong support from empirical studies. Bodnar et al., (1998) and Graham and Harvey (2001) provide survey evidence indicating that managers input their market views in their hedging decisions. Brown, Crabb and Haushalter (2005), Baker and Wurgler (2002), Adam and Fernando (2006) and Faulkender (2004) all document supporting evidence on the existence of "selective hedging". Empirical research, however, does not indicate any superior performance in relation to selective hedging (Brown, Crabb and Haushalter (2005), Adam and Fernando (2006)).

Another strand of opinion is derived from the relation between liquidity and corporate risk management policy. Corporate risk management is not independent from corporate financing policy. In fact, corporate financing policy inevitably affects: 1) hedging decisions; 2) the extent of hedging; and 3) the instrument choice. Parsons and Mello (2000) state that every hedging strategy comes with its own financing package and the advantages and disadvantages associated with hedging strategies are critical in determining both the value and success of alternative hedging strategies. Here the question that arises, what is the extent of the interaction between the financing policy and corporate risk management?

Moreover, the decisions to hedge as well as the optimal hedge ratio are both based on the firm's financing policy and financial constraints. Unless hedging is perceived as a substitute for equity capital, firms with little or no debt financing are not expected to benefit from hedging (Stulz, 1996; Parsons and Mello, 2000). Consequently, we expect firms with higher financial leverage and lower margins to be more incentivized to hedge than firms with no, or trivial, leverage or probability of financial distress. In line with the above argument, Purnanandam (2008) states that financially distressed firms in highly concentrated industries have higher hedging incentives compared to more financially capable firms. He further argues that there is a positive relation between hedging and moderate level leverage. This association, however, reverses for firms with very high leverage.

In addition to the timing and the maturity structure, the success of a hedging program is critically dependent on the instrument choice. The nature of the risk exposure and firm cash flows is an important determinant of the derivative financial instrument used Stulz (2002).

The nature of the risk exposure, that is the correlation between the price and the quantity risk is theorized to be a critically important determinant of whether linear (forwards, swaps etc.) or non-linear pay-off instruments (options) should be used to hedge (Stulz, 2002; Brown and Toft, 2002). Based on the nature of the risk exposure the literature has generally agreed on the following three arguments: 1) If there is a linear association between the price and the quantity risk exposure, that is as the price risk increases, firm level cash flows also increase linearly, then linear pay-off instruments (swaps, futures, forwards and collars) are preferred. 2) If there is no association between the price and the quantity risk exposure, that means zero correlation between price risks and internal cash flows, then non-linear instruments are preferred. 3) When the association (correlation) between the price and the quantity risk exposure is negative, the situation is close to a natural hedging (Gay, Nam and Turac, 2001; Brown and Toft, 2002; Bartram, 2004) and here non-linear hedging instruments provide more efficient hedging than linear hedging instruments. On the other hand, Parsons and Mello (2000) argue that the optimal hedging strategy is the one with a borrowing strategy that imposes the lowest financing costs on the firm.

The second element of the thesis conducts an ex-post hedging scenario analyses that compare the different hedging strategies available (to an airline company) first to a “benchmark” non-hedging strategy and then to the hedging program of Turkish Airlines (THY), an airline company that had not hedged its jet fuel price exposure until the year 2008 when the company started to hedge (20% of its expected 2009 fuel consumption). Both of these scenario analyses use the same inputs of jet fuel prices and pricing methodologies. The only difference between the two analyses is that, in the first one, the financial results of different hedging strategies are compared to a non-hedging scenario and in the second one the same results are compared to the *actual* financial results of Turkish Airlines. The second element of this thesis aims to find out answers to the following three questions:

1. Can an airline company receive any economically significant benefits from hedging strategies?

2. If the answer to the above question is yes, the next question asks whether selective hedging in terms of instrument choice is superior to the instrument choice based on the characteristics of the risk exposure which is widely accepted by the literature.

3. Can the hedging portfolio be fine-tuned using non-linear pay-off option instruments and combination strategies such as collars?

On a separate note, this section does not test for market timing as an evidence of "selective hedging". One reason for this is that, unlike oil producers, airline companies are not likely to have the necessary information advantage over the market. In fact, airline purchases of oil are relatively small compared to overall oil consumption. The aviation industry consumes around 1.5 billion barrels of jet fuel annually whereas the total consumption of petroleum products was 32 billion barrels in 2012. Consequently, the expected value of an information advantage is null (Morrel and Swan, 1996). Any expectation otherwise is deemed as speculating rather than hedging. As a result, the aim here is to assess the effectiveness of different derivative instruments available for commodity end-users conducting ex-post case study analyses.

First, ex-post scenario analysis where prices move ± 50% around their median levels observed in each year from 2005 to 2011 is conducted. Doing so produces a set of price observations (a distribution of simulated prices) with equally likely probabilities. This enables the calculation of the "effective fuel costs" that could be obtained using each derivative instrument in the range between the lowest 10th and 5th percentile effective fuel costs and the highest 10th and 5th percentile effective fuel costs obtained using 50% and 100% hedges. Effective fuel cost is calculated as follows:

$$EFC = Hedged\ \% \times Fixed\ Price + Non - Hedged\ \%\ \times Spot\ Prices$$

Next, single positions in derivative instruments including swaps, Asian options, collar strategies, participating collars and four-way collars are examined. Each instrument is compared to 1) a non-hedging benchmark scenario and 2) the financial results of Turkish Airlines in terms of their ability to benefit the airline company with potential fuel cost savings (in USD terms) taking into account the cost of obtaining the derivative positions and the position-wide risk exposure (the volatility inherent in the derivative position).

The risks of each derivative instrument used are evaluated using a simple Fuel Cost at Risk (hereafter, FCaR identical to Value at Risk) estimate which calculates the maximum (upper tail) and minimum (lower tail) 10th and 5th percentile of effective fuel cost from the simulated distribution of effective fuel costs that could be obtained using different derivative instruments.[5] The wider the range between these upper and lower tail FCaRs, the higher the volatility of the derivative position is expected to be. “Hedging efficiency” (HE from here on), which is the fuel costs saved as a percentage of the FCaR, is estimated in order to compare the risk and benefit profiles of each derivative instrument. The higher the ratio of “Fuel Costs Saved-to-FCaR”, the more efficient the hedging strategy is and the higher the benefits of a derivative position given its risk profile. In order to estimate the variability of the effectiveness of each hedging strategy, the standard deviation of the HE ratio is estimated for each derivative instrument. As Parsons and Mello (2000) state, the optimum hedging strategy is the strategy that doesn’t expose the hedger to a significant, additional volatility.

Next, combinations of non-linear-pay-off options and option strategies with linear-pay-off plain vanilla swaps are used in order to test whether the use of non-linear instruments can “fine-tune” the hedging portfolio. Brown and Toft (2002) define “fine-tuning” as the improvement in the convexity of the hedge portfolio. That is, increased cash flows from derivative positions. Gerner and Ronn (2012) define “fine-tuning” a hedging portfolio as the benefits accrued to the hedger in terms of reduced hedging costs and overall gross exposure. The “fine-tuning” criteria used in this section investigates whether the inclusion of non-linear instruments on existing swap positions make any additional contribution to the amount of fuel costs that could be saved, taking into account the costs of obtaining these combination positions and positional risks (standard deviations of positions). In that sense, it combines the definitions of both Brown and Toft (2002) and Gerner and Ronn (2012). The same risk-benefit analysis, using FCaR and HE, is conducted for the combination strategies and the

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[5] Value at Risk (VaR) measures the maximum amount that can be lost in a defined period of time (usually a day) as a result of risk factors with a given degree of statistical confidence such as 90%.

single derivative positions. This allows examine whether the total volatility of the HE is reduced when combining plain vanilla swaps with non-linear derivative positions. Using the terminology, it is a test on whether the linear pay-off derivative portfolio is fine-tuned using non-linear pay-off instruments.

1.4. Hedging with Futures and Options: The Role of Implied Volatility

The third element of the thesis investigates whether the use of market sentiment, measured by the implied volatility functions (IVF from here on) derived from oil options on futures (WTI options traded in NYMEX), provide useful information in the determination of derivative instrument choice for commodity end-users (i.e. airlines, shipping companies). There are several underlying motivations for this section.

The corporate risk management literature implicitly assumes that all hedging firms, regardless of the type of risk exposure (exposure to commodity prices, interest rates and/or currencies etc.), have the ability to use OTC derivative instruments which offer the flexibility to customize cash flow exposures in favour of the hedging firm. This is not the case, however, for the majority of the firms without the required credit rating needed to conduct a hedging program using OTC derivative instruments. For example, a derivatives usage survey by Bodnar et al. (1998) reveals that firms are concerned about counterparty risk, especially for longer-dated derivatives positions. They document that around 40% of the firms using derivatives insist on a credit rating of AA or better for their counterparty.

The liquidity position of a hedger is a function of the pay-off structure of derivative instrument(s) used as well as margin requirements of marked-to-market features of the exchange traded derivatives. The exchange broker will require the hedger to raise the cash balance to “maintenance margin” (the margin call) should the prices move in the opposite direction of the hedged positions. These marked-to-market features of exchange-traded derivative instruments can significantly affect the liquidity position of the hedger, particularly for the linear pay-off (futures) hedging instruments. An inability to raise the margin balance to “maintenance margin” due to insufficient liquidity may halt the hedging program before benefits from the positions are realized (Parsons and Mello, 2000).

Moreover, there is increasing evidence that hedging decision and instrument choice can also be explained through the examination of market conditions in addition to firm-specific characteristics (Brown, Crabb and Haushalter, 2005; Adam, 2003). As a result, this section aims to illustrate the potential association between the market information inherent in implied volatility function on crude oil options, and the choice of derivative instruments.

On the other hand, most of the option contracts on futures for crude oil in NYMEX, such as Light Sweet Crude Oil Option (CL), are American options and can be exercised as well as closed at the discretion of the hedger. These instruments, however, have up-front cash payments which may reach levels where the cost of hedging might outweigh the benefits from it. As a result, the input of the management’s expectations of the direction and variability of the price exposure can be important factors in the choice of hedging instrument when subject to marked-to-marked accounting and significant basis risk. The aim of this study is to test the usefulness of the market information (sentiment) inherent in the implied volatility functions (IVF) of Light Sweet Crude Oil (product code: CL) options traded in NYMEX in the determination of futures or options as a choice of hedging instruments.

If the IVF contains useful information as to the direction of the expected oil prices then it would be possible for an airline company who is subject to additional volatility in cash flows from the exchange traded instruments to utilize either of the strategies as a protection from price risks. For example if the IV of the crude oil indicates that directional risk of oil prices rests on long traders or commodity end-users who are naturally short the commodity, an airline company would position itself with short-term futures positions. On the other hand, if the directional risk of oil prices rests on short traders or commodity producers who are naturally long the commodity, an airline company might use options which allow it to establish position that provide upside risk protection but also allow it to take advantage of price falls.

The following section introduces the dynamics of the commodity markets and constructs the link between the implied volatility function as a measure of market sentiment and its potential role in guiding risk managers in their hedging instrument choice.

1.4.1. Dynamics of the Commodity Markets

The association between market sentiment (market risk aversion - measured by the implied volatility function) and commodity price risk management programs is attributed to the fact that commodities (particularly storable commodities such as oil) embed features of both financial assets and real assets. Financial asset prices reflect the long term discounted value of a stream of expected future revenues. In the case of stock prices, this future revenue stream may be eternal. In the case of a bond, the time is finite. Investors in financial assets are compensated for the risk of fluctuating cash flows. Conversely, speculators and investors in commodities earn returns for bearing short term commodity price risks. By bearing the price risk for commodity producers and commodity consumers, commodity investors and speculators are exposed to the hedger's short term earnings instead of its long term cash flows (Gorton and Rouwenhorst, 2006).

Despite the similarities between the pricing of financial assets and non-financial assets, there are distinct differences. Futures prices of financial assets are simply given by:

$$F(t,T) = S(t)e^{r(T-t)} \qquad 1.4.1$$

The above formula takes into account the time value of money and estimates the future price: $F(t,T)$, of an underlying spot price, $S(t)$, at time 0. Commodity markets are distinct in the sense that the above equation will also need to incorporate the physical benefits and costs of owning the asset as well as financial benefits and costs. Collectively, these inputs to pricing mechanisms will incorporate the market risk premium or futures premium.

Two models have been introduced as alternative prospects for the price formation of commodity futures prices and futures premium. The first model is the "hedging pressure" model which dates back to Keynes (1930) and Hicks (1939). The second model is the “theory of storage” of Working (1949) and Kaldor (1939), which explains the differences between contemporaneous spot and futures prices as a result of the interest foregone in storing commodity product, storage costs and a convenience yield on inventory.

According to the theory of storage argument net convenience yield, δ, of the commodity is defined as the flow of benefits which accrues to the owner of the physical inventory, i.e. spot commodity, but not to the owner of a contract for future delivery (Brennan, 1958). This can be explained in a similar way to dividend payments in equity markets. The monetary benefits from a dividend payment only accrue to the actual holder of the equity and not to the holder of a futures contract on the same equity. Since the futures holder doesn’t capture the value of the dividend payments, he/she observes the stock price drop after dividend payments by the exact amount of these dividend payments. On the other hand, the holder of the stock position will capture the values of dividend payments.

The above discussion can be similarly applied to commodity markets where dividends are replaced with the convenience yield. The marginal convenience yield, defined as the benefit of holding one extra unit of inventory, is a factor of the production value of the inventory. The physical holder of the commodity has the advantage in deciding whether it is more advantageous to liquidate or transfer the commodity to production. However, this advantage is not cost free. First of all, the physical holder of a commodity has to consider the financing costs: the interest foregone for financing the costs incurred in the transfer of a commodity from one location to another and the insurance and maintenance costs related to warehousing.

It is the first model; “the theory of hedging pressure” lays the foundation of the argument of this study which associates market sentiment and commodity price risk management programs. The hedging pressure model focuses on traders who participate in futures markets. It argues that traders’ net supply of futures contracts, or "hedging pressure," causes the equilibrium path of futures prices to contain an expected time trend. In Keynes' (1930) original theory, hedgers are endowed with long positions (e.g. airline companies as end-users of jet fuel) in the underlying commodity and thus take short positions in futures, resulting in equilibrium where futures prices tend to rise over time (termed backwardation).

More recently, Cootner (1960) recognizes that hedgers can be purchasers as well as producers of the underlying good, and can face quantity as well as price risk (Rolfo, 1980 and Anderson and Danthine, 1983). In these models, hedgers may take long and short positions (e.g. oil producers) in futures markets, resulting in an equilibrium where futures prices tend to decrease and increase over time allowing for both backwardation and contango term structures. These models imply that the sign of the futures risk premium varies cross-sectionally and inter-temporally as a function of the net holdings of hedgers Bessembinder (1992).

1.4.2. Normal Backwardation and Contango

The degree of uncertainty, and the resulting risk and direction of risk exposure, can be extracted from the term structure of commodity prices. Just like interest rate markets, commodity futures also exhibit a term structure which can be downward or upward sloping or can be humped in the short or long term ends. The shape of the term structure is a function that will be determined by the actions of hedgers and speculators.

The determinants of the forward curve can be illustrated with simple examples of commodity end-user and producer hedges. For illustrative purposes, assume the case of an oil producer in which the case hedger is concerned about a possible drop in oil prices. As a result, the hedger locks into the current price of oil by selling futures contract. This will transfer the oil price risk from the producer to the bank, a speculator or, preferably, a commodity end user. However, whoever is on the other side of this transaction is simply taking on the risk of the producer and must be lured to trade for this extra amount of risk. As a result, the producer agrees on a forward price level lower than the expected future spot price of oil. If $E(ST)$ is the expected spot price of the underlying commodity at the maturity of the contract and $F(t,T)$) is the time t agreed upon the price in the futures contract to be paid at time T. The difference between the agreed forward price and the expected future spot price:

$$E(ST) > F(t,T) \qquad 1.4.2$$

is the expected profit for the buyer of the futures contract.

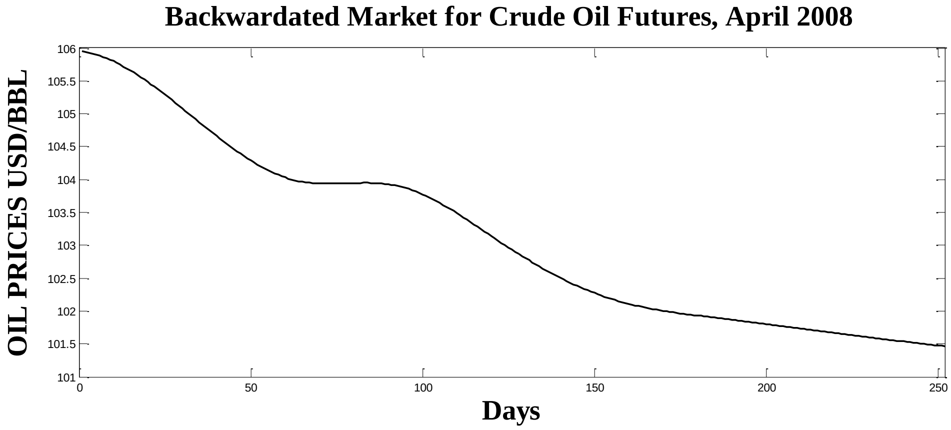

Figure 1: Backwardated Market for Crude Oil Futures, April 2008

Obviously, this profit level is not guaranteed and is subject to change should the market expectations on demand and supply for the commodity change. This condition, where futures prices are lower than the expected future spot prices, is referred to as "normal backwardation". Backwardation, on the other hand, is the situation where futures prices are lower than the current spot prices.

Backwardated markets have downward sloping futures curves. The longer dated the futures contract, the greater the discount must be compared to the expected future spot price to compensate the speculator for assuming a price risk for a longer period of time. Therefore, longer dated futures contracts are priced cheaper than shorter term futures contracts.

Normal backwardation on the other hand, is a desirable condition for the "net long" positions as futures/forward prices are expected to increase in order to align with expected future spot prices. The reverse situation to that of a backwardated commodity market is a contango market and is shown as:

$$F(t,T) > E(ST) \qquad 1.4.3$$

where the expected future spot price $E(ST)$ is less than the current futures price $F(t,T)$. Contango markets have upward sloping futures curves where longer dated futures contracts will have higher prices than shorter date contracts. Consider an airline company, A; naturally short crude oil. The single largest cost item in its business is fuel prices. This puts the airline company at risk to rising oil prices. The simplest way to hedge this exposure is to buy futures contracts. Also assume again an investor B; which could be a bank, a speculator or, ideally, a producer. B is on the opposite side of the trade to A. By buying futures, airline A aims to transfer its commodity price risk on to the other side of the trade. However, investor B must be lured to the market to sell the futures contract to airline A and to take on commodity price risk. Hence, airline A agrees on a futures price which is higher than the expected future spot price of oil. The difference between the futures price and the expected futures spot price, if preserved, will be the profit earned by the investor B.

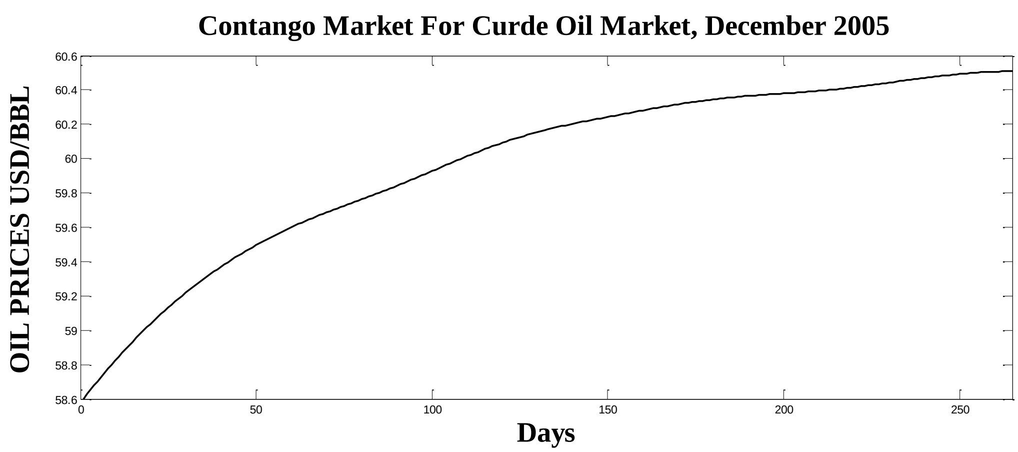

Figure 2: Contango Market for Crude Oil Market, December 2005

Since at maturity, spot and futures prices should converge, and given that the expected future spot prices do not change, contango implies that futures prices will fall over time as new information brings them into line with the expected future spot price.

Litzenberg and Robinowitz (1993) show that backwardation is a necessary condition to induce producers to produce. Production is shown to be an increasing function of the riskiness of futures prices. They state that backwardation stems from the trade-off between exercising the option (producing the oil) and keeping it alive (leaving the oil in the ground). It seems that whenever the market is weakly backwardated, that is the discounted futures prices are lower than current spot prices, producers will want to extract all of their oil, sell it in the spot market and use the proceeds to purchase future oil at a lower price. However, if discounted futures prices are higher than its spot price, producers will choose to defer production. In this case, they are protected against adverse price realization. Therefore, in order to induce them to extract some oil, weak backwardation is required. If the uncertainty about future prices is substantial, strong backwardation will be necessary in order to induce current production. Under certainty, the future spot prices are known and are equal to current futures prices. The introduction of uncertainty by itself does not necessarily lead to backwardation in the market.

Litzenberg and Robinowitz (1993) document that producers increase the extraction of crude oil and production as the spot price appreciates relative to future price. Hence, one should expect a positive relationship between production rate and backwardation rate. In addition, they find a negative relation between production rate and volatility (implied) in spot prices since higher volatility (higher call option prices) induces producers to defer extraction. And finally, a higher spot price of oil leads to an increase in current supply, whereas higher call option prices strengthen the incentive to defer production.

Hirshleifer (1989) examines the determinants of commodity futures hedging and of risk premia arising from co-variation of the futures prices with stock market returns and with the revenues of producers. He separates the risk premia into a stock market risk and a hedging pressure component and finds that stock market variability affects the incentive to hedge non-marketable risks and therefore affects the hedging pressure component of the premium. Good or bad news in the stock market, reflecting real wealth changes, affects the demand for different commodities. According to his model, production costs depend on output and output/demand shocks will typically be positively correlated, raising the premium.

The “hedging pressure” or “futures risk premium” idea has received some empirical support indicating that the movements in futures prices are correlated with hedgers' positions. Chang (1985) finds that price movements in three agricultural futures markets are related to the net positions of large hedgers and large speculators. He shows that prices rise more often than expected on a random basis in months when large speculators have net long positions and fall more often than expected in months when large hedgers have net long positions.

Moreover, examining financial, foreign exchange, metal and agricultural futures markets from January 1967 to December 1989, Bessembinder (1992) documents that returns in foreign currency and agricultural futures vary with the net holdings of hedgers, after controlling for systematic risks. More recently, Roon, Nijman and Veld (2000) provide evidence that the futures risk premium depends on both inter-market and cross-market hedging pressures. They examine 20 futures markets, divided into four groups (financial, agricultural, mineral, and currency) and show that after controlling for systematic risk, both the futures’ own hedging pressure and cross-hedging pressures from within the group significantly affect futures’ returns. They also argue that hedging pressure contains explanatory power for returns on the underlying asset.

Sometimes, the supply and demand of a commodity becomes unbalanced as was the case with crude oil in 2005. When this imbalance occurs, futures markets can reverse their natural course and flip between backwardation and contango. Similarly, a contango market can develop when the risk bearing shifts from commodity producers to commodity consumers.

Backwardated vs. contango markets depend upon a global supply and demand of the underlying commodity. In other words, it can depend on who bears the most risk of commodity price changes at any given time. When there is a production shortfall or instability in oil producing countries, crude oil prices are expected to increase. Consequently, the risk of crude oil price changes was felt squarely by oil consumers and not oil producers, in which case, markets will be in contango. A contango will occur when the most likely hedger of the commodity is naturally short of the underlying commodity. In this case, there will be a positive risk premium for short positions for bearing the consumers’ short term risks.

In contrast, when there is economic and political stability, and a surplus of inventories, the price risk rests on the shoulder of the producers and markets will be in backwardation. In this case, there will be a positive risk premium for long positions for bearing the producers' short term risks.

Implied volatility function (IVF) is used to capture the information content of the risk premium inherent in the futures market. IVF measures the risk awareness of the market participants. The link between the IVF and the choice of derivative instrument is the degree of market's risk aversion and the direction of the risk exposure (whether end-users or oil producers bear most of the risk). The testing hypothesis is parallel to Bollen and Whaley, (2004) who examine the relation between net buying pressure (net open short positions – long positions) and the shape of the implied volatility function (IVF) for index and individual stock options. They find that changes in implied volatility are directly related to the net buying pressure from public order flow. They also find that changes in the implied volatility of S&P500 options are most strongly effected by buying pressure for index puts, while changes in implied volatility of stock options are dominated by call option demand.

When plotted as a function of strike (moneyness) and/or delta market implied volatilities, options on the same underlying and maturities have a skewed shape which is called the volatility smile. Prior to the October 1987 market crash, this shape was symmetrical giving the appearance of a smile. Since October 1987, however, implied volatility function has been skewed, particularly in the equity and commodity markets.

There are several theoretical explanations for the asymmetric shape of the implied volatilities of different strike (moneyness) or delta options. One of the reasons is the leverage effect observed in the markets. This leverage effect is particularly visible in equity and commodity markets. In equity markets, the association between the volatility and the underlying prices are usually negative. Price falls are acknowledged as negative news and increase the risk aversion in the market which, in turn, creates negative steep in the implied volatility function. Investors secure themselves against the risk of prices falling further by taking positions in far OTM put options, which in turn results in higher volatilities for these far OTM put options compared to the ATM and OTM call options. Hence, there is a negative correlation between volatility and returns in the equity markets (Black, 1976).

On the other hand, in commodity markets it is usually price increases that are regarded as negative news. As a result, we expect to see positive skew (Geman and Nguyen, 2003) in the volatility function where far OTM call options have higher volatilities than ATM and far OTM put options as a result of the positive correlation between prices and volatility. In this case, the degree of risk aversion becomes higher and the price risk rests on the end-users. However, in some commodity markets, such as crude oil markets, implied volatilities can have negative skew (Alexander, 2009). This is likely to be observed when oil prices trend downwards for many months and the risk of oil prices rests on the producers' side. In this case, a majority of the producers would be buying OTM puts to protect themselves against further price falls. Another strand of opinion argues that the economic explanation for the skew is that the writer of the options (OTM) takes on a higher risk since he/she provides a hedge against large fluctuations in the underlying price.

The information value of the implied volatility function is tested for its ability to represent the market sentiment in oil price risk management using NYMEX oil futures and option contracts and as a guide to management in the determination of optimum derivative instrument choice. Market sentiment is measured by the changes in the delta normalized implied volatilities of the far OTM put options for the next month (prompt month) and the current month using options on oil futures traded in NYMEX. If the change is positive, market sentiment is bearish and traders take long positions in the far OTM put options. As a result, option instruments which take into account symmetrical risks (both price increases and price falls) are preferred. On the other hand, if the signal is bullish, where the change between the prompt month far OTM put IV and the current month far OTM put IV is negative, then futures/forwards or swaps are preferred.

Examining the time period from the January, 2006 to December, 2012, two different hedging strategies are examined. The first hedging strategy is futures only where the future contract is rolled over every month regardless of the informative signal from the IVF. In the second strategy, options on futures are chosen if the signal from the IVF is bearish. In the opposite case, if the signal from the IVF is bullish futures contracts are chosen.

1.5. Structure of the Thesis

The thesis is structured as follows. Section 2 examines the literature review on all three elements of this thesis. Section 3 explains the data used and different methodologies applied on each of the three elements. Section 4 provides results and Section 5 concludes and provides information on the areas of future research.

2. LITERATURE REVIEW

2.1. Introduction

Drawing from the frictionless market assumptions of the Modigliani and Miller (1958) framework, the corporate hedging literature theorizes and empirically tests both whether firms hedge and why firms hedge. Additionally, empirical studies question the hypothesis of shareholder value maximization via hedging. The literature proposes four rationales for corporate hedging and shareholder value maximization that are based on lowering cash flow volatility via hedging. Section 2.2 explains each of these rationales for risk management in greater detail.

The second element of this chapter investigates the literature on the determinants of derivative instrument choice which can be classified into 1) firm specific factors and 2) market-based factors. Firm specific factors state that the liquidity position of the firm and the nature of the risk exposure are important determinants of whether firms choose linear pay-off (futures, forwards and swaps) or non-linear pay-off (options) derivative instruments. On the other hand, market-based explanations argue the relevance of market conditions and managerial incentives to take advantage of their market-specific knowledge as the primary determinant on whether firms choose linear pay-off (futures, forwards, and swaps) or non-linear pay-off (options) derivative instruments. Both of these arguments are explained in greater detail in section 2.3.

Section 2.4 investigates the literature on informational role of the implied volatility function. Using the informational role of the implied volatility the third element of this study proposes and tests a new methodology to determine the optimum choice of derivative instruments for firms that are dependent on exchange traded derivative instruments which poses greater cash flow volatility and basis risks.

2.2. Hedging and Firm Value

2.2.1. Tax Based Incentives

The tax incentives argument states that hedging reduces the variability of pretax earnings and expected taxes payable, which in turn increases firm value (Smith and Stulz, 1985; Nance et al. 1993). For example, assume firm A has the following EBIT (earnings before interests and taxes); $100M, $200M, $150M and $100M for the last four consecutive years. Firm B has the following EBIT (earnings before interests and taxes); $130M, $170M, $125M and $125M for the last four consecutive years. Assume the statutory tax rate is 25% for EBIT below $150M and 30% for EBIT at, or above, $150M for both firms. The total taxes paid by firm A will be; $25M, $60M, $45M and $25M for each of the years. Whereas the total taxes paid by firm B will be; $32.5M, $51M, $32.25M and $32.25M for each respective year. Despite the same level of profitability (EBIT), all else equal, the total taxes paid will be $155M for firm A and $146M for firm B. The only difference between the two firms is the variability in their earnings schemes. Hence, when the statutory tax regime is convex, reduced volatility in pre-tax earnings can reduce taxes paid.

However, empirical evidence on the tax convexity motivation for hedging has not been strongly and uniformly supported. Graham and Smith (1999) use a simulation method to analyse more than 80,000 firms in the U.S. They find that 50% of their sample face convex effective tax functions and 25% face linear tax functions. They show that approximately one-quarter of the companies with convex tax functions can obtain substantial tax savings from hedging - a result that is consistent with Smith and Stulz (1985). Contrastingly, Graham and Rogers (2002) investigate the currency derivative holdings of 442 firms from 1994 to 1995 and test whether firms hedge to increase the debt capacity of interest tax deductions and report that firms do not hedge in response to tax convexity. They find, however, that firms hedge to increase debt capacity.

In addition, Foo and Merlyn (2009), Mian (1996) and Gézcy et al. (1997) find no evidence of tax convexity incentives for hedging. Shanker (2000) shows that the tax incentive to hedge is conditioned on the ability to move tax loss carryforwards both forward and back.

The second argument for tax incentives for corporate hedging is the expected benefits of tax shields obtained from debt financing (Morellec and Smith, 2007). As a result of increased debt financing, firms enjoy greater tax shield benefits (Graham and Rogers, 2002). Even though the increased financial leverage might result in agency problems, such as the underinvestment and/or asset substitution problems (Mayers and Smith 1987), Leland (1998) argues that the expected tax benefits from increased leverage are much higher than the agency related costs.

2.2.2. Firm Risks and Financial Distress Costs

Despite its tax shield benefits, increased leverage brings the risk of direct and indirect costs of financial distress (Smith and Stulz, 1985). Nance et al. (1993) argue that the probability that a company will face financial distress costs increases as the proportion of fixed claims in total assets increase. Hedging reduces the expected costs of bankruptcy by reducing the variance of firm value (Mayers and Smith, 1982; Smith and Stulz, 1985). Additionally, Purnanandam (2005) develops a theoretical model in which there is a positive association between the incentives to hedge and financial distress costs. However, this relationship is inversely related with the degree of financial leverage.

Empirical research provides some support for the financial distress hypothesis. Examining the determinants of the corporate hedging decisions of 771 firms for 1992, Mian (1996) provides consistent evidence of hedging with respect to financial distress costs and firm size. Campello, Lin, Ma and Zou (2011) indicate that hedging can lower the odds of negative realizations, thereby reducing the expected costs of financial distress.

There is also strong empirical support on derivatives use and firm risk reduction. The majority of these studies focus on foreign currency risk exposure and derivatives use. Examining 6,888 non-financial firms from 47 countries, Bartram, Brown and Conrad (2008) find strong evidence that the use of financial derivatives reduces both total risk and systematic risk. Jorion (1990) examines the exposure of U.S. multinationals to FX risk. He finds evidence that the relationship between stock returns and exchange rates differs systematically across multinationals and the co-movement between stock returns and the value of the dollar is positively related to the percentage of foreign operations. Similarly, Bartov, Bodnar and Kaul (1996) examine the relation between exchange rate variability and stock return volatility for U.S. multinational firms and break this relation into components of systematic and diversifiable risks. They find that significant increases in the volatility of monthly stock returns correspond to a period of increased exchange rate variability. Moreover, Allayannis and Ofek (2001) examine whether firms use foreign currency derivatives for hedging or for speculative purposes. They use a sample of S&P 500 nonfinancial firms for 1993 and find that firms use currency derivatives for hedging and significantly reduce their exchange rate exposures. In contrast, Hentschel and Kothari (2000) examine 425 large U.S. corporations and find that compared to firms that do not use financial derivatives, firms that use derivatives show no significant differences in risk.

2.2.3. Managerial Incentives

Misalignment of management and shareholder interests is considered to be an important determinant of corporate hedging. The management is likely to have an appetite for risk that may not necessarily conform to the shareholders' best interests (Smith and Stulz, 1985). This is usually the case when a large portion of a managers' personal wealth is strongly tied to the value of the business. Managers that are unable to diversify away personal wealth from company-specific risk factors become more risk-averse and might be more inclined to hedge to reduce firm level risks (Smith and Stulz, 1985).

Stock options provide greater flexibility in terms of wealth diversification and might offer the management greater incentives to take risks. Smith and Stulz (1985) argue that there are greater incentives to hedge if the managers' compensation depends on stock performance and the managers are unable to diversify away their wealth from firm specific factors. Tufano (1996) examines the North American gold mining industry and provides empirical evidence that managerial incentives are an important determinant in hedging decisions. That is, firms whose managers hold more options manage less gold price risk, and firms whose managers hold more stock manage more gold price risk.

2.2.4. Underinvestment Incentive

Finally, Froot et al. (1993) investigate the role of hedging on firm-level capital investments under imperfect markets assumptions. They argue that the underinvestment problem occurs if corporations forego profitable investment opportunities when they have a cash flow shortfall and/or face costly external financing. The uncertain nature of cash flows creates a mismatch between the timing of available internal cash funds and investment opportunities, leaving corporations with two options when they have insufficient amount of internal cash funds: they can either forgo profitable investment opportunities or they can resort to external financing.

In reality, debt financing is constrained by direct and indirect costs such as issuance and transaction costs (Myers, 1977), asymmetric information problems (Myers and Majluf, 1984), and contracting problems (Jensen and Meckling, 1976; Myers, 1977). Hedging is beneficial to the extent that it can reduce the variability in operating cash flows and thus preserve internally generated funds that can be used in value-adding investment opportunities without the need for costly external financing.

The underinvestment hypothesis has received some support. Geczy, Minton and Schrand (1997) examine the use of currency derivatives and argue that firms with greater growth opportunities and tighter financial constraints are more likely to use currency derivatives. Similarly, Gay and Nam (1998) analyse the underinvestment problem as a determinant of corporate hedging policy. They find evidence in support of a positive relation between a firm's derivatives use and its growth opportunities. For firms with enhanced investment opportunities, derivatives use is greater when they also have relatively low cash stocks. Firms whose investment expenditures are positively correlated with internal cash flows tend to have smaller derivatives positions, which suggest potential natural hedges.

More recently, Campello, Lin, Ma and Zou (2011) use a tax-based instrumental variable approach and provide evidence that hedgers pay lower interest spreads and are less likely to have capital expenditure restrictions in their loan agreements. They find that hedging is a one-standard-deviation increase in hedging intensity and is associated with a reduction of about 54 basis points in loan spreads. In theory, this should ease a firm's access to credit. Additionally, a one-standard-deviation increase in hedging intensity reduces the probability of having an investment restriction covenant by 20%. They also indicate that hedging is more valuable for borrowers facing a higher likelihood of financial distress.

2.2.5. Value-Relevance of Hedging

Starting with Allayannis and Weston's study (2001), literature on corporate risk management shows a great deal of interest in empirically examining the association between derivatives use and firm value using the theoretical underlyings of corporate risk management. Allayannis and Weston (2001) studied the direct relationship between hedging and firm value, examining foreign currency derivative use in a sample of nonfinancial U.S. firms between 1990 and 1995. They use Tobin's Q as a measure of firm value and observe that hedging is associated with a value premium of 4.87%.

Studies following Allayannis and Weston (2001), however, provide conflicting evidence on shareholder value maximization and hedging. Bartram, Brown and Fehle (2004) use a large sample of 7,319 non-financial companies in 50 countries from 2000 to 2001 to examine the impact of interest rate and foreign exchange derivatives usage on firm value. They document that the usage of derivatives is a value-adding activity, and the result is more significant for interest rate hedging than foreign exchange hedging. Graham and Rogers (2002) also provide consistent evidence on hedging in response to financial distress costs, firm size investment opportunities, and the increase debt capacity and therefore firm value. Moreover, Mackay and Moeller (2007) show that risk management can add value when revenues and costs are non-linearly related to prices. Using a sample of 34 oil refineries, they find that hedging concave revenues and leaving concave costs exposed would represent between 2% to 3% of firm value.

On the other hand, Mian (1996), Guay and Kothari (2003) and Tufano (1996) provide conflicting evidence on hedging and shareholder value maximization. For example, for 234 large non-financial companies, Guay and Kothari (2003) report a smaller than anticipated magnitude of cash flow exposure to derivative instruments. They argue that the value premium observed for hedging firms in the literature are overstated. Similarly, Bartram et al., (2011) provide positive but weak evidence on the use of financial derivatives and firm value. They further argue that results are sensitive to endogeneity and omitted variable problems.

More recent studies examine the product market and the real market consequences of hedging. Campello et al., (2011) study the implications of hedging on corporate financing and investment. They show that hedging reduces the expected cost of financial distress and eases firms' access to credit. They provide evidence that hedgers pay a lower interest spread and are less likely to have capital expenditure restrictions in their loan agreements. Similarly, Cornaggia (2013), examining the effects of risk management on productivity using data from the U.S. agricultural industry, argues that the use of derivative instruments increased productivity. Gonzâlez and Yun (2013) study the effect of risk management on productivity and find that financial innovation and the use of derivative instruments increases firm value.

2.3. Hedging Effectiveness and Derivative Instrument Choice

There are three reasons why commodity price risk management is both economically and statistically meaningful. First, the cash flow exposures to commodity prices are significant for both commodity producers and end-users. Second, commodity prices exhibited significant volatility over the last decade. And lastly, information regarding hedging positions and derivative instruments is available in greater detail for these companies compared to other non-financial corporations.

There is, however, completely conflicting empirical evidence on the association between hedging and shareholder value creation for commodity producers and commodity end-users. Examining U.S. oil and gas producers from 1998 and 2001, Jin and Jorion (2006) find evidence against hedging and firm value creation. They do, however, confirm that hedging reduces stock price sensitivity to oil and gas prices. Similarly, examining North American gold miners, Tufano (1996) finds weak evidence of value creation via hedging. Carter et al. (2006), however, study hedging and firm value relations for the U.S airline industry and report that hedging is associated with a value premium of 5% to 10%.

The decision to hedge and the choice of derivative instruments are dependent on several firm specific and systematic factors. The most comprehensive evidence on derivatives use and underlying motivations is provided by Bodnar et al., survey (1998). They show that the use of derivatives is much higher among large firms (83%) than it is among small firms (12%), and higher among primary product firms (68%) and manufacturers (48%) than it is among firms in the service industry (42%). They also show that the success of corporate risk management is measured on the basis of its ability to help obtain target profit levels rather than reduced volatility. Approximately 40% of the firms chose increased profit relative to a benchmark or absolute profit rather than reduced volatility (40%) or risk adjusted performance (21%).

They also show that the percentage of firms using options is an increasing function of firm size. Approximately 74% of large firms that used derivatives indicated the use of some form of option within the past 12 months. This compares with 58% of medium-sized firms and 47% of small firms. By industry, manufacturing firms were most likely to use options with 78% indicating some use compared to 67% of primary product firms and 50% of service firms.

Finally, option combinations are most commonly used by primary product firms. The derivative-using firms that did not use options were asked to provide an explanation for this decision. The overwhelming explanation for not using options focused around their costs with a substantial number of firms complaining that they were “too expensive”. Among the other explanations for non-use of options are stated as these instruments being inappropriate for the firm's exposure or that other instruments being better suited for their exposures and that the firm lacked sufficient or adequately trained staff in order to use options.

Firm specific reasons in the choice of derivative instruments are outlined by Brown and Toft (2002), Stulz (2003), Gay, Nam and Turac (2001). All three papers state that the most important determinant of whether a firm chooses linear pay-off instruments or non-linear pay-off instruments is the nature of its risk exposure. If the risk exposure is linear in nature (meaning it does not change according to variations in risk factors, and is independent of these factors), then linear pay-off instruments (swaps, futures) are effective in hedging the exposure. If the risk exposure is non-linear in nature (meaning it *does* change in response to variations in risk factors), then non-linear pay-off instruments (options) are preferred.

A particular measure of the nature of the risk exposure is the correlation between price and quantity risks. An optimal hedging portfolio consists of a varying combination of linear and non-linear risk management instruments depending on the correlation between price and quantity risk. If the correlation between the two is negative, that is as the price risk increases the output decreases or vice versa, a natural hedge occurs in which the quantity risk (over or under production) is offset by factor prices (higher or lower price risk). In this case, the optimal hedging portfolio shifts towards more non-linear instruments and the overall demand for the derivative instruments (hedging) decreases (Brown and Toft (2002), Stulz (2003), Gay, Nam and Turac (2001)). As expected, the degree of substitution will depend on the correlation between output levels and market prices, the firm's financial leverage, and its transaction cost structure Gay, Nam and Turac (2001).

A positive correlation between output and prices will have the opposite effect. So, when the correlation is positive, prices will be more likely to be low in those states where a firm has over-hedged (realized low output). Consequently, the firm's overall demand for derivatives will increase because, in addition to reducing price risk, derivatives can be used to reduce a portion of the firm's business risk. A positive correlation between output and prices will also help mitigate a firm's potential over-hedging problem associated with using linear contracts. As a result, when compared to the zero or negative correlation cases, such firms will have a greater demand for linear contracts and a lower demand for non-linear instruments Gay, Nam and Turac (2001).

In general, however, options are very flexible hedging instruments, and portfolios of options can be constructed to hedge simple and complex, linear and non-linear exposures (Bartram, 2004). For example, Brown and Toft (2002) argue that a long position in put options is often superior to selling forward contracts when price and quantity risks are negatively correlated. They show that price and quantity correlation, the degree of price and quantity volatility, and the ratio of these risks are the primary determinants of the optimal hedge's convexity. For example, firms should typically buy convexity (i.e. options) when the correlation is negative.

In addition, Brown and Toft (2002) state that firms can benefit most from non-linear exotic pay-offs when the correlation between the price and quantity is negative and the quantity risk is large. If the correlation between price and quantity is negligible, forward contracts are typically very effective hedging tools. When the correlation is positive, exotic derivatives offer additional gains over forwards or options alone and these gains increase with greater quantity risk and less price risk.

Recent empirical evidence, however, provides support for “selective hedging”, whereby the management inputs its own market opinion into a hedging decision (Stulz, 2003). Selective hedging is referred to as market timing in most cases. The management adjust the extent to which a given risk exposure is hedged based on its expectations of uncertainty in prices. Survey evidence from Bodnar et al., (1998) indicates that 32 % of firms that use derivatives reported that their market view of exchange rates leads them to “actively take positions” at least occasionally. A similar result is found in the market view of interest rates.

Examining the North American gold mining industry from 1993 to 1998, Brown, Crabb and Haushalter (2005) document significant time series variation in risk management policies as a result of changes in managements’ expectations. They state that changes in hedge ratios are positively associated with changes in gold prices. In other words, companies hedge more when gold prices increase and hedge less when gold prices decrease. They offer as evidence the statistically significant ability of producers to favourably adjust hedge ratios, however, the economic gains from selective hedging are very small and lower than for an alternative technical trading strategy. They find no evidence that selective hedging leads to superior operating or financial performance.

Similarly, examining the North American gold mining firms from 1989 to 1999, Adam and Fernando (2006) find that these companies managed to earn positive cash flows (hedging gains) of $3.9BN, on average, from the use of derivative instruments. However, they find no evidence to suggest that, firms incorporating their market views into their hedging programs and speculating on time does not create any value for shareholders on average. They argue that consistent, positive gains from derivatives use are related to ever-present systematic positive risk premia in the gold market where forward prices are above the future spot prices, a case called “normal contango”. They further document evidence of excess volatility in a firm’s hedge ratios over time and state that firms incorporate their market views into their hedging, supporting the argument of “selective hedging”.

The scope of the “selective hedging” hypothesis also covers the choice of instrument depending on managerial expectations. Adam (2003), examining the gold mining industry, shows that the decision to use non-linear hedging strategies (option strategies) is mostly a function of market conditions and to a lesser extent due to the non-linearity of the exposure. The two factors that significantly influence the decision to use non-linear hedging strategies are the gold price and the gold price volatility. He argues that if market volatility is high, firms are less likely to choose option strategies. At low prices, cash inflows will be low which increases the maturity mismatch between cash inflows and outflows. In this situation, non-linear hedging strategies may be preferable. Gold mining companies that use convex (long put option) strategies are also among the most diversified and profitable with the highest debt, lowest liquidity levels and the most likely to have a credit rating. In contrast, firms that use concave (short call option) strategies are among the least diversified with the lowest debt and the highest liquidity levels. He finds, however, no statistically significant relation between the size of investments and the use of non-linear pay-off hedging strategies.

More recently, Gerner and Ronn (2012) conduct a case study approach on an international air carrier managing its jet fuel risk exposure. They use the carrier's self-defined objective function for risk management and show that the air carrier could "fine-tune" its current hedging portfolio by adding tailored exotic options. That is to say, the use of annual average price options (Asian options) leads to a superior position in terms of hedging costs and the firm's overall gross exposure to jet fuel price fluctuations, confirming the theoretical findings of Brown and Toft (2002).

2.4. Hedging with Futures and Options: The Role of Implied Volatility

The early literature examining the information content of the implied volatility finds supporting evidence on the information content of the implied volatilities on predicting future realized volatilities. Latané and Rendleman (1976) examine 39 weekly observations of options in 24 stocks from October 1973 to June 1974 and show that implied volatility is better than historical standard deviation at forecasting future realized volatility. Similarly, Schmalensee and Trippi (1978) examine 56 weekly observations for options on six stocks from April 1974 to May 1975 and document that implied volatility is a superior measure of future realized volatility. Chiras and Manster (1978) use 23 monthly observations from June 1973 to April 1975 but in a difference to the above papers, they control for dividend payments. They find that during the first nine months of the sample, implied volatility is not significantly better than historical volatility (HV) at forecasting volatility. After the nine-month period, however, they observe that implied volatility is a better forecast of future realized volatility than historical volatility. They state that their results could have been the result of a slower market reaction to the opening of the Chicago Board of Exchange (CBOE) in 1973 after which the volatility forecasts are incorporated into option prices. Overall, when examining the predictive content of implied volatility (IV), the early literature provides evidence that IV explains variation in future volatilities better than HV.

However, recent studies examining options on individual stocks or options on the cash S&P 100 index find that IV is a poor forecaster of the future realized volatility (RV) (Kumar and

Shastri, 1990; Randolph et al, 1990; Day and Lewis 1992; Canina and Figlewski 1993; Amin and Ng 1997; Dumas, Fleming and Whaley, 1998).

Among these studies, comparing the information content of the implied volatilities derived from call options on the S&P 100 index to GARCH models, Day and Lewis (1992) find that IV has some predictive power, but that GARCH and/or HV improve this predictive power. Canina and Figlewski (1993) examine the predictive ability of the IV of the future RV using S&P 100 index options. They find that in aggregate and cross-sectional analyses implied volatility has virtually no correlation with future volatility (realized volatility) and does not incorporate the information contained in recently observed volatility. Strong and Dickinson (1994) show that call options on the S&P 1000 index over the 1984-88 period provide evidence that the level of future price volatility implied by Black and Scholes (1973) contains both an ex post factor related to historical return volatility and an ex ante factor related to past levels of implied volatility. A joint use of historical and implied volatility provides a more accurate forecast of realized volatility. Amin and Ng, (1997) study the information content of implied volatility using several volatility specifications from Heath-Jarrow and Morton (HJM) models in the Eurodollar options market. They find that IV calculated from the HJM models explains much of the variation of realized interest rate volatility over both daily and monthly horizons. Dumas, Fleming and Whaley (1998) use S&P 500 options from June 1988 through December 1993 and examine the predictive and hedging performance of the deterministic volatility function option valuation model vs traditional implied volatility function. They show that DVF is not a better model than the traditional IVF derived from Black and Scholes' model (1973).

Jorion (1995) examines the predictability of volatility in the foreign exchange market using implied volatilities derived from options on foreign currency futures traded in the Chicago Mercantile Exchange (CME). He finds that volatility forecasts using IVFs are biased.

Contrary to the above, however, Christensen and Prabhala (1997) find that IV outperforms past volatility in forecasting future volatility. They argue that the regime shift around the October 1987 crash explains why implied volatility is more biased in previous work. More recently, Becker, Clements and White (2006) examine whether the S&P 500 implied volatility index (VIX) contains any information relevant to future volatility beyond that available from model-based volatility forecasts. They find that the VIX index does not contain any such additional information that is relevant for forecasting volatility. Ryu (2012) investigates the information contents of an implied volatility index based on Korea's index options contract. He studies the in-sample and out-of-sample forecasting performance of the implied volatility index using the recent 100-month-long volatility index series constructed using KOSPI200 index and option prices. He finds that IVF from the KOSPI200 index outperforms GARCH models.

In addition, more current studies look at the relation between the information content of the IVs and stock price performance. Among these, Gârleanu et al., (2009) argue that when investors have relatively pessimistic perceptions, they tend to buy put options either for protection against, or speculation on, future stock price drops. This increase in the demand for put options leads to a higher price and implied volatility, yielding a steeper volatility smile. They argue that stocks with a high volatility skew should therefore underperform stocks with a lower skew.

Xing and Zhao (2010) find that stocks exhibiting the steepest smirks in their traded options underperform stocks with the least pronounced volatility smirks in their options by 10.9% per year on a risk-adjusted basis. They further state that this predictability persists for at least six months, and firms with the steepest volatility smirks are those that experience the worst earnings shocks in the following quarter. Their results indicate that informed traders with negative news prefer to trade out-of-the-money put options and confirm one of the reasons for the asymptotic skew observed in the implied volatilities of different strike options.

There are, however, very few papers that examine the predictive power of the IVs in the commodity markets as the majority of the work is concentrated on stock markets. Day and Lewis (1993) examine crude oil futures using daily data from November 1986 through March 1991 and compare GARCH type volatility models with implied volatility models on call options. In sample tests, they find no superior estimation of GARCH type models over the implied volatility. In out-of-sample tests of forecasts of future volatility, GARCH type models appear to violate the requirements for forecast rationality, whereas implied volatilities do not. Similarly, Szakmary et al., (2003), using data from 35 futures options markets, test how well the implied volatilities (IVs) embedded in option prices, predict subsequently realized volatility (RV) in the underlying futures. They find that for a large majority of the commodities studied, the IVs outperform historical volatility (HV) as a predictor of the RV in the underlying futures prices over the remaining life of the option. They also argue that HV contains no economically significant predictive information beyond what is already incorporated in IV.

2.5. Summary

Section 2 presents theoretical and empirical literature on whether and why firms hedge, implications of corporate risk management, the determinants of derivative instrument choice and the role of implied volatility on predicting future volatility and stock prices.

Empirical studies on hedging incentives provide mixed evidence particularly for the tax based explanations of corporate incentives for risk management. On the other hand, the underinvestment theory and managerial incentives for corporate risk management are generally supported. The literature agrees on the reduced variability in cash flows and reduced firm-level risk for firms that hedge, however, value-relevance of hedging is only supported for commodity end-users, such as airline companies, but not supported for commodity producers and mining companies. This contrast in results for commodity price risk management is one of the underlying motivations for this thesis as mentioned in sections 1.1 and 1.2.

The literature brings two broad explanations on determinants of the choice of derivative instrument used by hedging firms. The first argument proposes the view that derivative instrument choice is determined by firm specific factors such as the liquidity position of the firm and the nature of the risk exposure. Firms with greater liquidity are more likely to use non-linear pay-off derivatives which might require upfront premium. On the other hand, the choice of derivative instrument depends on the correlation between the pay-off from the risk exposure and the derivative instrument itself. If the risk exposure is linear in nature (meaning it does not change according to variations in risk factors, and is independent of these factors), then linear pay-off instruments (swaps, futures and forwards) are effective in hedging the exposure. If the risk exposure is non-linear in nature (meaning it *does* change in response to variations in risk factors), then non-linear pay-off instruments (options) are preferred.

The second argument proposes that market based factors play an important role in the determination of the type of financial instruments used. Marked based factors are defined as the price and volatility of the underlying risk exposure combined with the management willingness to exert their so called market knowledge in their hedging decisions. Overall, this strand of opinion suggests a term called “selective hedging” where the hedging activity is carried out opportunistically rather than for variance minimization purposes.

The third element of this section documents evidence on the information content of the implied volatility function (IVF). Empirical research shows that there are strong time series properties inherent in IVFs. Early research demonstrates that IVF is superior to historical volatility in forecasting future realized volatility. More recent research, however, provides contrasting evidence. There are only a few papers that tests the information content of the IVF on commodities and only one of them provide evidence in favour of the informational role of IVF. Next section introduces the data and methodologies used in each three elements of this thesis.

3. DATA and METHODOLOGY

3.1. Introduction

This section introduces to the sources of data and methodologies used in all three elements. For the first element the starting point is the Compustat Global database that provides information on all airline companies around the world. This data is then screened according to a number of selection criteria which significantly increase the quality of the data in order to carry out the analysis for the study. The information obtained from this database is merged with the hedging data obtained from 10-K, 10-q reports, annual reports and company presentations. Stock price data is obtained from Bloomberg and Datastream which then used to calculate the Tobin's Q. The sample period is for 11 years, from 2000 to 2012 which, after the selection criteria results in 54 global airline companies with 411 firm-year observations.

For the second element the primary data is the jet fuel price data (CIF NWE Rotterdam) obtained from Datastream for 6 years period from 2005 to 2011. The analysis in this study needs to have a forward curve, market-proxy swap prices, Eurodollar futures data, and risk free interest rates in order to test the questions outlined in section 1.3. Two-factor Pilipovic (1998) model is used to construct forward curves. Swaps are priced using the forward-price adjusted Eurodollar futures which are used to construct zero-coupon curves. Finally the section applied a series of option pricing techniques including Monte Carlo simulations that are used to price Asian type options. Jet fuel price data is simulated $\pm$50% around each year's mean price observation which forms the basis of simulated jet fuel prices. In that sense the approach is in between Bootstrapping and Monte Carlo simulation. For each of the 6 year period examined, a number of efficiency measures are estimated which enable one to compare hedging and non-hedging strategies as well as the efficiency of different derivative instruments.

For the third element, implied volatility data is obtained from Bloomberg. Bloomberg data is limited to the year 2006 and onwards hence the study is limited to 2006 to 2012. Bloomberg provides three measures of implied volatility; sigma IV, Moneyness IV and Delta-neutral IV. This study use Delta-neutral IV which is perceived as the most accurate way to analyse historical behaviour of a particular option with a given delta.

3.2. Hedging and Firm Value

The Compustat Global database with a SIC code of 4512 is used to collect data on global airline sample which results in 972 firm year observations. In order to achieve as much economically meaningful data as possible, three selection criteria are applied to this data sample. First, the airline must be publicly traded to calculate the Tobin's Q ratio. Second, in order to prevent endogeneity, it must operate in the passenger business (excluding cargo carriers) but not be a regional carrier. Appendix 1 shows that regional carriers transfer the fuel cost burden (and the related volatility in their operating cash flows) to the major carriers through operational hedging[6]. And finally, it must disclose sufficient information on its use of fuel derivatives, including the percentage of jet fuel consumption hedged[7]. After the exclusion of small jets with a trivial scale of business, the above selection criteria results in data from 60 airline companies. Of these 60 airline companies, 6 disclose insufficient hedging and other operational data, resulting in a final sample of 54 airline companies. Examining the time period from 2000 to 2012 provides 411 firm-year observations in total. This is the largest data in the literature that uses hedging percentage data for a global sample of companies as opposed to the less informative dichotomous hedging dummy variables. Similarly, this is also the first global airline sample studied with actual percentage hedging information to date with 13 U.S., 14 European and 27 international airline companies.

The test variable, the percentage of the next year's fuel consumption hedged, is readily available for most airline companies that have an established risk management policy. The availability of this data avoids the hazard of making subjective assumptions about the size, scope, and tenure of derivative contracts.

As Jin and Jorion (2006) state, to prevent endogeneity in hedging and firm value variables, it is preferable to have a dataset that incorporates firms with different levels of hedge ratios. Table 1 Panels A, B, and C exhibit the descriptive statistics of the hedging percentages and control variables. Panel A summarizes the hedging and non-hedging firm-year data for the total sample and the low-cost and major airlines sub-samples. Columns 2 to 10 show that

[6] Similar to fuel surcharge data, the availability of this data also remains company specific outside of the U.S.

[7] The advantage of the airline industry is that the data related to jet fuel price hedges are easier to obtain in comparison to many other industries. Economically, there is a substantial difference between 5% hedging and 50% hedging, regardless of the scope of the risk exposure (whether it is a commodity or currency risk or a combination of both). The economical substance of the actual amount of fuel consumption hedged would be disregarded by the use of dichotomous hedging variables, which would be a non-trivial oversight for the airline industry.

hedging levels range from zero to 90%. These sub-samples yield 88 non-hedging-firm year and 323 hedging-firm year observations. On average, 60% of the low-cost carriers sample and 44% of the major carriers sample are hedging less than their group average hedge levels and 25% and 35% of the airlines are hedging less than 10% and 20%, respectively. The average hedging levels of each group are summarized in Table 1, Panels B and C, as 34%, 32%, and 34% for the "total sample", "low-cost carriers", and "major carriers", respectively. The similarity in the hedging levels reassures that the sample does not suffer from the endogeneity problem. Table 1 also provides summary statistics for the U.S., European, and international airline company regional sub-samples that we examine the robustness of our results.

In order to gather fuel hedging levels and financial data from company annual and quarterly reports, 10-K filings are used. The stock price data is obtained from DataStream and Bloomberg to calculate Tobin's Q as a measure of firm value.[8] There are many different ways to estimate the Q value but there is a lack of consensus as to the best measure (Whited, 2001). A simple approximation suggested by Chung and Pruitt (1994), also used by Carter et al. (2006), gives unadjusted Q measure as:

$$Q = \frac{MVE + BVPS + BVD}{TA} \qquad 3.2.1$$

The numerator is the summation of the market value of equity (MVE), which we estimate by multiplying the number of shares outstanding with share price, the liquidation value of preferred stocks outstanding (BVPS), and the book value of short and long-term debt (BVD). The denominator is total assets (TA).

In order to more reliably reflect the assets, liabilities, operational leverage, asset turnover and profitability measures, control variables are adjusted for off-balance-sheet leases. Following Damodaran (2002), the present value of operating leases (PVOL) are added back to assets and liabilities and obtain Q values (Adjusted Q) that reflect the impact of hidden assets and

[8] Tobin's Q is the replacement value of firm's assets. The measure is frequently used as a proxy for firm value in the corporate finance literature; Shin and Stulz, 2000; Allayannis and Weston, 2001; Carter et al., 2006; Jin and Jorion, 2006; Bartram et al., 2011 among others.

liabilities that take into account the true amount of firm commitments. The adjusted measure of Tobin's Q for the robustness test performed is:

$$AdjQ = \frac{MVE + BVPS + BVD + PVOL}{TA + PVOL} \qquad 3.2.2$$

Column 9 in Panels B and C of Table 1, show the unadjusted and adjusted values for Tobin's Q. After adjusting for off-balance-sheet leases, the largest reduction in the average value of Tobin's Q is observed for the low cost carriers with off-balance sheet leases at 41% of their total assets compared to 24% compared to major carriers. The relatively lower asset base for these companies is the main reason for the drop in Q value but this has no impact on our findings. Columns 2 and 3 of Panels B and C show the amount of expected fuel consumption hedged and the average percentage of fuel costs in total operating expenses.

The airline companies in the sample that do not hedge in any year of the sample period examined are Jet Airways, Kingfisher, and SpiceJet (India)[9]; Jazeera (UAE); Asiana (Korea); and Hainan and China Southern (China[10]). However, some airlines hedge sporadically, and when they do hedge, it is usually a small percentage of their fuel consumption. Turkish Airlines (Turkey) did not hedge until 2008 and since then has only hedged between 10% and 20% of total consumption. Allegiant (U.S.) hedged insignificant amounts (10% and 2% in 2006 and 2007, respectively) and stopped hedging in 2008. Air Arabia (Saudi Arabia) did not hedge from 2007-2010 and then only hedged 17% and 25% in 2011 and 2012, respectively. Similarly, US Airways abandoned hedging in 2008 and has not hedged since.

For the instrumental variable regressions one-year ahead expected oil prices are gather from the base-case projections of "Annual Energy Outlook" published by U.S. Energy Information Administration (EIA). This means that $year_1$ forecast of crude oil prices are used as an instrument in the instrumental variable regressions which assumes that the test variable, hedging is an endogenous determinant of firm value. More precisely, $year_1$ forecast of crude

[9] To our knowledge, there is no regulatory sanction on hedging for Indian airline operators.
[10] We note that the Chinese government banned the use of derivative instruments for Chinese airline companies in 2009 but lifted the ban in 2012.

oil prices are assumed to influence airline companies' hedging decisions on $year_0$. The data for the availability of managerial stock options and the level of off-balance sheet leases used as a percentage of total assets, is collected the data from annual reports and 10-K statements.
A limitation of the study is that the sample is constrained by the lack of consistency in the disclosure of hedging data for non-U.S. airline companies. European airline companies only started to disclose the necessary information on fuel risk management after the implementation of International Accounting Standard 32 (Disclosure of Financial Instruments, IAS32) for financial years beginning in January 2005, prior to which disclosure had been voluntary. Some of the international airlines do not fall under the umbrella of the International Generally Accepted Accounting Principles (iGAAP) or U.S. Generally Accepted Accounting Principles (US GAAP). Having controlled for regional differences, there is no evidence that the accounting, financial, and economic fundamentals of airlines that voluntarily disclose such information are materially different from mandatory disclosers. These techniques result in an unbalanced panel, but provide the most diversified sample of the airline industry.

In order to examine the potential impact of the excluded airline companies' appendix 3 of this thesis investigates the association between firm value and hedging using hedging dummy variables. These companies which are excluded from the main analyses but included in the dataset examined in appendix 3 are Aeroflot (Russia), Norwegian Air Shuttle (Norway); Malaysian Airlines (Malaysia), Korean Air Lines (South Korea), Croatia Airlines (Croatia) and finally Virgin Australia (Australia). Additionally, the dataset in appendix 3 also include firm year observations for some of the already-included firms, particularly for years prior to the year 2005. These airline companies are mainly non-U.S. firms which only started to disclose relevant hedging data after the implementation of the IFRS accounting system. Overall, the use of dichotomous hedging variable results in 476 firm-year observations. It should be noted that the low cost carrier sub-sample gained only two firm-year observations.

3.3. Hedging Effectiveness and Derivative Instrument Choice

3.3.1. Forward Price Curves

Forward prices, hence forward curves, are key inputs in derivatives pricing, risk management and hedging. Ideally, a forward curve is expected to capture the characteristics of the spot market prices. The limitation of the one-factor models discussed above is that they are unable to capture the inverse relationship between the short end of the forward curve and the long end. There usually is a very small correlation between the short end and the long end of the forward curve indicating that we need models which can capture the characteristics of both ends of the forward curves. This is the main argument for the development of two factor stochastic models in which one factor captures the behaviour of the short term forward prices while another factor should capture the behaviour of the long term forward prices.

Only two factor models can model the commodity forward curves which are similar to interest rate curves, which can be falling (backwardated), rising (contango), humped in the short end (contango in the short end and backwardated in the long) and vice versa Pilipovic (1998). Forward prices are risk factor adjusted expectations of spot prices in the future. In complete markets, there are many liquid instruments available that can be used for trading and hedging purposes. Yet in an incomplete market, choices of instruments are sometimes limited and we are left with a system-wide uncertainty. In other words, we cannot eliminate all risks in our portfolio using markets. This risk is captured by the market price of risk, λ which is the excess return markets demand over the risk free rate, r for accepting the market risk. The market price of risk is given by:

$$\lambda = {}^{(\mu - r)}/_{\sigma} \qquad 3.3.1$$

In order to estimate the forward curve, crude oil prices (CIF NWE Rotterdam) were obtained from Datastream for the period between 2005 and 2011. Similarly Eurodollar futures are obtained from Bloomberg for the same period. Eurodollar futures are adjusted for short futures position bias, which are then used to estimate forward prices.

3.3.2. Two-Factor Pilipovic Model (1998):

The two factor Pilipovic model assumes that long term mean level to which prices are expected to revert to, L_t, follows a geometric Brownian motion.

$$dS_t = \alpha(L_t - lnS_t)dt + \sigma S_t dZ_t \qquad 3.3.2$$

$$dL_t = \mu dt + \sigma_L L_t dW_t \qquad 3.3.3$$

Where the correlation between $Z_t$and W_t, $\rho_{z,w}$ is zero.

S_t: spot price
L_t: long term equilibrium price
α: rate of mean reversion
σ: spot price volatility
σ_L: equilibrium price volatility.

The formula for the forward pricing is given as:

$$F_{t,T} = \left(S_t - \left(\frac{\alpha}{\alpha+\mu}\right) L_t\right) e^{-(\alpha+\lambda\sigma_E)\tau} + \left(\frac{\alpha}{\alpha+\mu}\right) L_t e^{(\mu-\lambda\sigma_E)\tau} \qquad 3.3.4$$

With a reasonable assumption that the mean reverting rate, α being significantly higher than the drift: μ enables the following assumption:

$$\left(\frac{\alpha}{\alpha+\mu}\right) \approx 1 \qquad 3.3.5$$

As a result, the formula for the forward price is given by:

$$F_{t,T} \approx (S_t - L_t)e^{-(\alpha+\lambda\sigma_E)\tau} + L_t e^{(\mu-\lambda\sigma_E)\tau} \qquad 3.3.6$$

When risk adjusted mean reversion is substituted: $\acute{\alpha} \equiv \alpha + \lambda\sigma_E$ with the risk adjusted growth rate $\acute{\mu} \equiv \mu - \lambda\sigma_E$, the formula further simplifies to:

$$F_{t,T} \approx (S_t - L_t)e^{\acute{\alpha}\tau} + L_t e^{\acute{\mu}\tau} \quad 3.3.7$$

The estimates of forward curves for CIF NEW Jet Fuel are presented in Table 8. Column 1 shows the contract months in days. The column extends to the 720th day (2 years) into the future. Columns 2 to 8 show the estimated prices for the term structure. The limitation of the estimated forward curves is that they are likely to be different from actual forward curves available for the specific time in question. For example, traders could have quoted a higher/lower price for one year oil contracts. This information, however, is extremely hard to obtain. This is particularly the case for oil contracts with maturities extending beyond two years and the reason why forward curve estimations in this study are limited to two years of maturity.

3.3.3. Derivative Instruments Available for Commodity End-Users

The derivatives provider is defined as the counterparty that bears the ultimate market risks embedded in any derivative. Derivative traders usually determine the price of an instrument by using empirical and mathematical models, and then add the bid-offer spread. This bid-offer spread usually includes risks such as 1) credit risk, counterparty risk and 2) contract risk: exposure of a hedging portfolio to changes in, for example, the regulation of the market, taxation or changes in indices plus a profit margin that takes into account the risks related to the hedging of the positions.

Market liquidity is a crucially important factor to consider in energy risk management, not only in its initiation, but throughout its entire life. Liquidity directly affects the effectiveness of a hedging program. Liquidity can be separated into two components: price liquidity and quantity liquidity.[11] The price liquidity is the spread, which is the difference between the price at which traders are willing to sell and the price at which the traders are willing to buy.

[11] Crude Oil Hedging, Energy Security analysis, Inc, *Risk Books, Energy and Power Special Reports,* 1998

Most important, however, is the quantity liquidity, the uncertainty related to the ability of the markets to execute large orders or a large number of orders, usually in a short period of time, without generally distorting prices.

Before establishing a transaction, counterparties, particularly the swap providers, need to know that further-out liquidity is sufficient to establish some prospect of a reasonable hedge. Illiquid markets will be more liable to basis risk and hedging the exposure may be inefficient.

Liquidity concerns affect the choice of maturities and volumes when hedging. Assume that the trader wants to sell a jet CIF NWE swap to an airline. If the term of the swap is for one year, then the exact quotes for swap prices are generally available from other traders or brokers, meaning, the market is quite liquid. However, if the term of the swap is for more than three years, the pricing gets more complicated. Although pricing is still possible through other traders or brokers, informing the market of your intentions in illiquid markets often is risky (Kaminski, 2005). This is due to the fact that other traders can run the bid ahead. An alternative strategy is to devise a swap price by calculating the different elements of the equation: the underlying crude oil swap. For example, using the Brent and adding the Brent/gasoil crack and adding the Jet fuel/gasoil crack to obtain a swap price for jet fuel contracts. When structures are complex or difficult to hedge, swap providers will build this risk into the swap price using correlation coefficients.

The success of a specific type of derivative instrument depends on the derivative provider's (market maker/trader) ability to market the product and dynamically hedge its residual risk. Marketing is the process of gaining relationships with potential clients. Dynamic hedging is the constant monitoring and adjustment of different risk portfolios and is largely dependent on the availability of market liquidity. In majority of the cases, derivative providers (market makers) are left with a positional residual risk. That is, the risks in their portfolios do not balance out and offset each other. This can be a result of differences in timing, product specification and size. In these cases, swap traders are often forced to warehouse certain market risks such as product or time-spread risks.

Forward curve risk, however, is more damaging than basis risks which affect the whole range of derivative instruments rather than individual products. Moreover, an end-user's strategy will be significantly dependent upon the shape of the term structure (backwardated or contango) and the volatility in prices. The dynamic structure of the commodity markets can render any potential transactions uneconomical in a very short span of time. Many trading opportunities and the investors' interest in potential derivative transactions can disappear following almost any movement of the forward curve, price volatility or exchange rates. Additionally, and unique to the oil market, the signals carried by oil price are used not only as a trading tool but also as a basis for the management of stocks and processing units. In deregulated markets, this results in an operational connection with the trading and hedging decisions of refineries, power plants and other industrial facilities Pilipovic (1998).

In fact, the availability and popularity of the derivative instruments for commodity end users (airline companies in this thesis) are dependent on the availability of the liquidity and risks embedded in specific instruments. Linear pay-off derivative instruments available for commodity risk management purposes include average pay-off swaps, crack swaps, participation swaps, differential swaps, double-up swaps, swaptions, extendable swaps, pre-paid swaps, complex swaps and curve lock swaps (Kaminski, 2005). Some of these instruments are, however, tailored for the needs of energy producers such as crack swaps and differential swaps. Some are too risky for pure-hedgers such as an airline company but serve the needs of traders and speculators. These include double-up swaps, complex swaps, curve lock and backwardation swaps and require constant monitoring (dynamic hedging). For example, double-up swaps offers the swap provider the right to double the hedging quantity at the initial or lower fixed price. If an airline company engages in a double-up swap agreement with a bank, it essentially buys a swap and sells a put option on a similar swap (similar to swaption). This granted right to the writer reduces the initial hedging costs at the expense of the potential opportunity cost of inverse price movements, particularly during volatile periods.

Non-linear pay-off derivative instruments available for commodity risk management include Asian options, average-strike options, Lookback options, Barrier options, Spread options and

Basket options. Other than Asian options, all of these exotic options available for commodity risk management purposes are more expensive than standard European options. For example, Lookback options are much more expensive than the corresponding European option and as a result, the popularity of the option is very low (Kaminski, Gibner and Pinnamaneni, 2005). Similarly, from the point of the option writer Barrier options may present formidable hedging difficulties (Benson and Daniel, 1991). These factors render these instruments illiquid and hence, inefficient. The most popular option strategy is the Asian type which has a path dependent pay-off structure which dampens the volatility associated with commodity prices, reducing the premium paid in advance as a result (Geman, 2005, 2008). Below, derivative instruments that are widely applied in commodity end-user risk management strategies are examined.

This study makes two strong assumptions that are acknowledged as the limitations of this section: First of all, the start date of Libor-based spot rates are assumed to extend to the futures' maturity date exactly and computed rates comprising the zero-curve are assumed to have maturities corresponding to the futures' maturity dates. Consequently, estimations are free from any maturity mismatch and related cash flow problems. Next, it is assumed that hedging instruments carry no basis risk. In practice, there are three types of basis risk:

1. Product basis: This is the most important basis risk in most risk management markets, including energy markets. If there is a mismatch in quality, consistency, weight, or other specifications, then the underlying product and the hedge are not fungible. In energy markets, there are a large number of products and only a few liquid hedging instruments. Consequently, illiquid underlying exposures are often hedged with a liquid instrument, the price of which is linked to a different instrument. Even when the instrument's underlying price shows a strong historical correlation with the underlying exposure, significant basis risk can emerge if the relationship between two products breaks down.

2. Time Basis: This is common enough in many markets but it can be particularly dangerous in energy markets when there is a sudden shift in demand or transportation bottlenecks occur.

3. Locational Basis: Prices of exactly the same product can vary significantly from one location to another. For example, Platt's report prices for 1% sulphur fuel oil in both the US Gulf and New York Harbour, as well as a similar 1% low sulphur fuel oil in Rotterdam. In OTC swaps markets, the price differential normally shows New York Harbour at premium which roughly reflects the cost of shipping the oil up from the Gulf.

Most of the time, there is no perfect hedge where the timing of cash flows from derivative instruments exactly matches that of the actual spot price exposure. Additionally, a hedger might be exposed to a product basis where the derivative instruments traded or made available over the counter do not match the actual spot product to which the company is exposed to. Having acknowledged these limitations, the following sections estimate forward curves and derivative prices.

3.3.4. Swaps

Plain Vanilla Swaps

Swaps are the exchange of a series of future cash flows. The buyer of a swap agrees to pay a pre-agreed fixed price or rate (the swap price) in return for a floating price or rate at pre-specified time intervals until the maturity of the swap.

In the case of an end-user commodity price risk management, a swap buyer as a fixed rate payer obtains protection for prices above any pre-agreed swap rate but they are exposed to downside price risk should the prices fall below the swap price. Commodity swaps usually involve the monthly exchange of cash flows which better fits to airline companies' spot price exposures. Additionally, unlike plain vanilla swaps on interest rates, a floating rate is determined using the daily or weekly average of the observed benchmark prices such as Platts Gulf Coast Jet Fuel.

Pricing Swaps

It is easier to illustrate swaps pricing using interest rates and then transferring the pricing to commodities. The "swap price" refers to the fixed rate payment of the swap. It is the rate at which the swap buyer agrees to pay to the floating rate buyer a predetermined notional amount of the underlying in return for a floating rate for the same underlying. To better illustrate the cash flows involved in swaps consider two bonds: one with a fixed rate couponB^{Fix}, and the other with a floating rate coupon B^{Flt}. We can value these two bonds as follows:

$$B^{Fix} = \sum_{t=1}^{n} \frac{C^{fix}}{(1+r)^t} + \frac{F}{(1+r)^n} \qquad 3.3.8$$

$$B^{Flt} = \sum_{t=1}^{n} \frac{C^{flt}}{(1+r)^t} + \frac{F}{(1+r)^n} \qquad 3.3.9$$

where,

B^{Fix}: fixed coupon bond price
B^{Flt}: floating coupon bond price
C^{fix}: fixed coupon rate
C^{flt}: floating coupon rate
F : face value of the bond
r : risk free interest rate

If we define V as the value of the swap, we can show the value of a "*receive fixed, pay floating" swap* as a combination of a long position in a fixed rate bond and a short position in a floating rate bond so that:

$$V = B^{fix} - B^{flt} \qquad 3.3.10$$

Similarly, we can show that a "*pay fixed, receive floating*" swap can be shown as a combination of long and short positions in floating and fixed rate bonds:

$$V = B^{fix} - B^{flt} \tag{3.3.11}$$

There are two points in swaps pricing:

1. Unless it is agreed otherwise, swaps are designed to have zero value at the initiation. At time 0, the value of a fairly priced swap is zero.

2. The value of a floating rate bond is equal to its par value which is $1, at either issuance or upon any reset date

The value of the swap is found under these conditions as:

$$\$0 = B^{fix} - B^{flt} \tag{3.3.12}$$

$$\$0 = B^{fix} - \$1 \tag{3.3.13}$$

$$B^{fix} = \$1 \tag{3.3.14}$$

The equation (2.17) above indicates that the “price” of a swap will be the coupon rate that makes the fixed rate bond value equal to the floating bond rate value, which is $1 at the initiation and at the reset date, making the initial value of the swap zero.

The discount rate used in swaps pricing is usually Libor-based which represents the true cost of USD borrowing for major non-US banks. Counterparties to swap agreements can be of various credit qualities. These differences in credit qualities are not accounted for in the pricing but through master agreements which specify a number of provisions aimed at mitigating credit and legal risk.

In order to obtain different discount rates for calculating the present values of each cash flow and their corresponding maturity, a Libor-based zero coupon curve is used. A bootstrapping technique is used in order to derive the rates corresponding to maturities which are not quoted in the market. The short end of the zero coupon curve is easier to construct as actual Libor-market quotes exist for these maturities. However, the mid-to-long end of the curve is derived from forward rate agreements (FRAs) or Eurodollar futures.

Eurodollar futures, traded on the Chicago Mercantile Exchange, are among the world's most liquid and heavily traded futures due in large part to their central role in the pricing and hedging of interest rate swaps. Eurodollar futures are, in essence, cash-settled futures on three month Libor-based deposit rates. Quotes on Eurodollar futures prices are readily available for maturities extending to 10 years. Prices are quoted in such way so that to find the associated implied futures rate, we must first subtract the observed futures price from 100.00. Consider a Eurodollar futures quoted at 95.00. To find its associated implied futures rate, we must subtract this price from 100.00 and obtain a rate of 5.00%. The standard contract size for Eurodollar futures is $1 million notional. Thus, a one basis point change in price corresponds to a $1,000,000 x 0.0001 x 90/360 = $25 change in contract value.

The use of Eurodollar futures rates as a proxy for the forward rates that are used to construct the zero-curve raises some important points. The daily marked-to-market settlement procedure in futures markets is biased towards the short position. We can show this with a simple example: assume that a Eurodollar futures contract is trading at 95.00 (an implied futures rate of 5%). For each contract, there will be a long and short position. If the futures price increases 100 basis points to 96.00 (which yields an implied futures rate of 4%), then, following daily resettlement, the long position will show a credit or profit of $2,500 (100 basis points times $25 per basis point). These funds are then invested elsewhere to earn 4%. On the other hand, the account of the short position will show a loss of $2,500, which is financed at 4%. Consider instead the result of a 100 basis point decline in price to 94.00 (implied futures rate of 6%). In this case, the long position incurs a loss of $2,500, which is financed at 6%. The short position earns a $2,500 profit, which is invested at 6%.

If price increases and decreases are assumed to be equally likely, then the daily settlement feature of futures markets clearly favours short positions. When a short position is in credit, it can be re-invested at higher interest rate levels. However, when a long position is in credit, it can be re-invested at relatively lower rates than a short position. Similarly, when a short position is in debit it can finance its collateral at a lower interest rate than is the case when a long position is in debit.

Longs recognize this disadvantage and thus require compensation to induce them to be counterparty to trades. Thus, shorts will agree to a lower equilibrium price than they would otherwise in the absence of daily resettlement. As a result of the lowered futures price, the implied futures rate becomes an upward biased proxy for the desired forward rate. This bias will become more severe 1) the longer the time to the futures maturity date which means greater number of daily resettlements and 2) the longer the duration or price sensitivity of the asset underlying the futures contract. In order to correct for the bias, a “convexity adjustment” is applied to the futures rate. A reasonable and simple approximation for the convexity adjustment is given by Hull (2008):

$$Forward\ Rate = Futures\ Rate - (0.5) \times\ \sigma^2\ \times T1\ \times T2 \qquad 3.3.15$$

In the above expression, σ is the annualized standard deviation of the change in the short-term interest rate, *T1* is the time (expressed in years) to the futures maturity date, and *T2* is the time to the maturity date of the implied futures rate.

Table 9 presents the results of convexity adjustments from 2005 to 2011 to all the implied futures rates assuming a value of 1% for annualized standard deviation σ. The first column (CM) lists the contract maturities available. For the maturities below one year, there are 8 contracts available. For each year after the one year period, there are four maturities available. The “Price” column under each year represents the convexity-adjusted price for each forward contract. The “Rate” column under each year represents the implied forward rate estimated from forward prices. The implied forward rate is estimated as follows: Face value of the Eurodollar futures; $100 as convention, minus the convexity adjusted forward price; $97.4 for January 2005 contract multiplied by 10000 basis points and presented in percentage.

Next, Table 10 displays a zero-curve constructed using bootstrapping technique and interpolation in which short-term Libor spot rates are combined with forward rates to derive the discount rates of unquoted maturities.

Commodity Swaps

In a similar way to the interest rate swap pricing example, we can calculate the value of a commodity swap at time 0 as:

$$V = \sum_{t=1}^{N} \frac{C^{fix} - C^{flt}}{(1+r)^t} \qquad 3.3.16$$

Equation (2.9) implies that the value of a commodity swap can be expressed in terms of the portfolio value of a series of N forward contracts. Simply solve for the fixed price of the commodity C, which makes the overall value of the swap equal zero.

In the case of an end-user commodity risk management, hedger will be long the swap where he/she pays a fixed price for the commodity in question (natural gas, oil, gasoline, etc.) and receives a pre-specified benchmark market price for the underlying such as Platts Henry Hub Natural Gas index futures.

Participating Swaps

A participating swap is very similar to the participating collar structure. The only difference is that the strike prices of the options bought and sold are the same and are usually chosen to be equal (usually in-the-money depending on the forward prices). Just as with the participating collar structure, the hedger (end-user of a commodity instrument in this case) acquires 100% protection for prices above the agreed strike but only participates in the price risk below the strike. Like the participating collar, a participating ratio is defined as the ratio of the size of the put option sold to the size of the call option purchased.

The idea behind the participating collar is to structure long and short sides of the trade such that the total amount of premiums paid for each option and have zero cost structure. If, for example, a participation swap is agreed at a level of $100 per BBL WTI with 50% participation, the buyer would be fully protected against prices above $100 per BBL, but would also capture 50% of the benefits when prices fall below $100 per BBL. The participating feature is achieved by selling a put option with a desired participation level:

$$Participation\ Level = \frac{Total\ number\ of\ the\ put\ options\ sold}{Total\ number\ of\ the\ call\ options\ bought}$$

3.3.4.1. Options

Options give the contract buyer (long position) the right, but not the obligation, to buy or sell the underlying asset at a pre-agreed price (known as strike) in return for an up-front insurance premium reflecting the riskiness of the position and a profit margin for the seller. To price options on spot underlying commodity, the most used method is the Merton option pricing model (1973). This model shares all the assumptions of the BSM model (1973), such as constant and known risk free rate and volatility and the underlying stochastic process (Geometric Brownian Motion), but here the stock is expected to make a dividend payment in continuous time.

The most common model used for options on futures is the Black model (1976) which is discussed in pricing swaptions. In other words, the holder of the stock will receive a dividend, δ. In the context of commodities, the dividend δ is the convenience yield. Just as dividends only accrue to the owner of the physical stocks, a convenience yield also accrues to the holder of the physical commodity not the holder of a derivative position.

Asian Options Pricing

An Asian option is a type of option where the pay-off of the option is calculated either as the difference between a pre-defined strike price, K, and the average of the observed market prices, $A(S)$. A different type of Asian option is the one where the strike price is determined as an average, $A(K)$ instead of the observed market prices.

These options are particularly popular in foreign exchange and commodity markets as they better reflect the actual cash flow exposure of companies. To illustrate: an international airline company purchases jet fuel from contracted suppliers at different locations on certain days each week. This means, the airline company's cash expenses for fuel are spread throughout a

given month. Since commodity options and swaps are settled monthly regardless of the term of the contract, monthly averaging represents the true spot fuel price exposure better than plain vanilla swaps or options.
Averaging is typically calculated using an arithmetic average. A weighted average may also be used to fit the risk exposure of the option buyer better. For example, a weighted average Asian option, in which weights which are determined to be an inverse function of the time to expiration, can be used to hedge a series of planned fuel purchases that are likely to increase in volume. Airline companies have increased demand in the summer months during which they will also be using more jet fuel compared to other periods. Therefore, using weighted averaging may better reflect their actual cash exposure to oil consumption and may provide more efficient hedge.

An additional benefit of Asian options is that these instruments, owing to the smoothing mechanism of the averaging feature and resulting in lower volatility, have cheaper premiums compared to standard European options. However, Geman and Yor (1993) state that although the volatility is the most important input in option pricing, it is not the only one. They show that if the convenience yield is positive and very high, or in other words, if the forward curve is in steep backwardation (where $r - y$ is negative), an Asian call option may be more expensive than a European call with the same characteristics. If the convenience yield is very low or negative (where $r - y$ is positive), an Asian call option will indeed be cheaper than the standard European option

There are four types of Asian options in which the average is geometric or arithmetic. When the average is for the value of the underlying spot price the option is called the arithmetic/geometric average price option. When the average is for the value of the strike the option is called arithmetic/geometric average strike option However, geometric averaging is less popular and seldom used.

If an Asian option is traded when it is within its averaging period, then the averaging effectively starts from the date when the option is purchased. In this case, the average price to date will be incorporated in the pricing. The pay-off structures for these options are shown below:

Average price call and put option pay-off are given by:

$$c = \max[0, (A(S) - K)]$$

$$p = \max[0, \left(K - A(S)\right)]$$

Average strike call and put option pay-offs are given by:

$$c = \max[0, \left(S - A(K)\right)]$$

$$p = \max[0, (A(K) - S)]$$

Another advantage of the averaging feature of Asian options is that their pay-offs are less sensitive to any extreme market conditions that may prevail on the expiration day. A large player in a rather less liquid market can easily move prices just prior to expiration, whereas when the pay-off is based on the averaging market, manipulation becomes much more difficult.

From the point of view of the option writer, Asian options are preferred products because they are easier to hedge. Asian options with long averaging periods do not have the high gamma risk that may befall ATM European options near their expiry date. After the Asian option enters its averaging period and the average begins to set, the gamma risk of the option decreases and approaches zero near the end of averaging options with reasonably long averaging periods. If the averaging period is only two or three days, the gamma may still be sizeable at expiration.

Average Price Options

The pricing of European options in the Black and Scholes (1973) framework is straightforward when stock prices are assumed to follow the lognormal distribution. The underlying pricing process under this assumption is the geometric Brownian motion. However, the applicability of this formula to Asian (or any other path-dependent options) is not that simple. This is because even though prices themselves follow geometric Brownian motion, arithmetic averages of prices are not lognormal. There are, however, several proposed methods for pricing these instruments. These include: Geometric Approximation (Kemna and Vorst, 1990), BSM approximation, (Alexander, 2009) and Monte Carlo Simulations. Asian option prices calculated using these methodologies are presented in Table 11. This study uses Monte Carlo methodology to price Asian options and the methodology is described below.

Monte Carlo Simulation

Monte Carlo technique is particularly useful in pricing path-dependent options like Asian options. One needs to choose an appropriate underlying price process such as Brownian motion or mean-reverting and simulate N paths of commodity prices from time period 0 to T. Using geometric Brownian motion with a drift term adjusted for convenience yield, y, we have:

$$\frac{dS(t)}{S(t)} = (r - y)d_t + \sigma dW_t \qquad 3.3.17$$

Then, applying Ito's lemma, we have the following formula for the underlying prices:

$$S(\Delta t) = S(0)\left[exp\left(r - y - \frac{\sigma^2}{2}\right)\Delta t + \left(\sigma\sqrt{\Delta t}\right)\right] \qquad 3.3.18$$

Once the underlying price process is chosen, the next step is to calculate pay-offs from price observations and a given strike price.

$$c_{Avg.Payoff} = \max[0, (S_A - K)] \quad for\ call\ options$$

$$p_{Avg.Payoff} = \max[0, (K - S_A)] \quad for\ put\ options$$

The averaging is usually arithmetic and discrete:

$$S_A = \frac{S(t_1)+S(t_2)+S(t_n)}{n} \qquad 3.3.19$$

These pay-offs are discounted back to day 0 by using a risk free interest rate so that:

$$c_A = e^{-rT} \max[0, (S_A - K)] \quad for\ call\ options$$

$$p_A = e^{-rT} \max[0, (K - S_A)] \quad for\ put\ options$$

Despite its intuitive sense and ease of application, one disadvantage of the Monte Carlo methods is that one cannot precisely estimate option Greeks. This is simply because we do not have an explicit pricing formula for Asian options only approximations. However, Asian options cannot be priced using the BSM model because even though the individual component prices will be lognormally distributed, an average of prices will not. Since there is no known closed form solution for the distribution of the average, Asian options are priced using numerical solutions, closed form approximations or Monte Carlo simulations.

3.3.4.2. Collars

Collar strategies are a combination of call and put options and are very popular in the jet fuel risk management programs of airline companies. There are several reasons why these strategies are so popular particularly in the airline industry. First of all, jet fuel prices account for more than 30% of their total operating expenses becoming the single most important manageable risk factor in the industry. As a result, the amount of contracts required to carry out a hedging program is substantial. Additionally, airline companies operate in a fiercely competitive, high costs / low margins environment. The average level of profitability measured by "Return on Assets" has been a mere 3% in the last decade which is not even enough to cover the cost of capital. As a result, airline companies are extremely cost conscious. Given the recent increase in the volatility of oil prices and the high level of prices, the cost of hedging using derivatives instruments[12] substantially increased.

As a result airline companies have been forced to look for alternative ways to hedge their jet fuel price exposures. Collar strategies involve the simultaneous purchase and sale of call and

[12] In 2010, US Airways CEO stated that it would cost the company around $330M to hedge its jet fuel risk exposure and company felt indifferent between being hedge and unhedged as they decided benefits from hedging would not exceed the cost of hedging

put options in order to achieve the minimum or zero upfront cost for the hedging using options.

Costless Collars

Costless collars are a combination of a long call option and a short put option, in the case of a commodity end-user hedge, and a short call option and a long put option in the case of a commodity producer hedge where the premium paid in the long position is equal to the premium received in the short position. This is the simplest collar structure which aims to achieve a zero cost option position in a given underlying commodity.

In the case of an end-user hedge, this strategy provides 100% protection for the upside price risk should prices increase above the call strike. However, it also exposes the hedger to a 100% downside price risk should the prices fall below the put strike. As a result, there is a trade-off between zero upfront costs and an accepted extra risk on the downside. Below is the pay-off structure of a collar strategy from the simulated data for 2007.

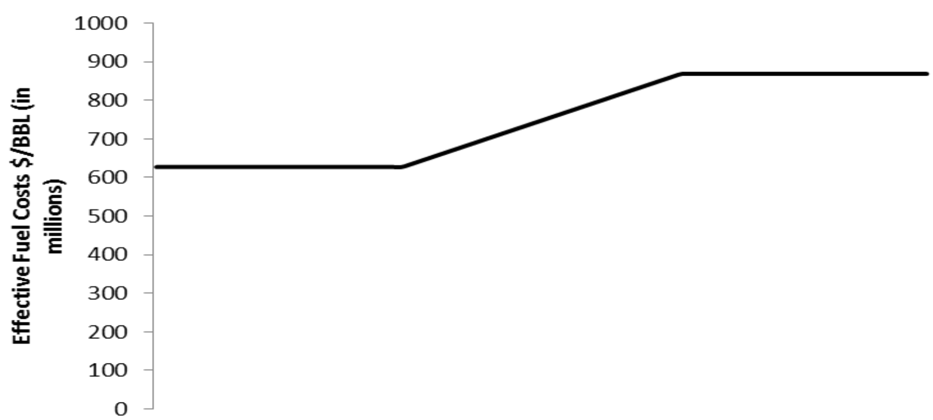

Figure 3: Pay-off Structure of a Collar Strategy for 2007

3.3.4.3. Four-way collars

When a company wants to obtain protection for both rising and falling prices simultaneously, a 4–Way Collar is one of the possible strategies. One of the most appealing features of this strategy is that it can be constructed at minimum or zero cost and provides a price range at which the hedger is comfortable enough to utilize spot markets, outside of which the hedger has limited gain and loss potential. A 4-way collar is the combination of a call option spread and a put option spread. If the company in question is the commodity end-user, then the strategy involves purchasing an OTM call option with a strike price usually at 110% of the current forward price and then selling a second OTM call option with a higher strike price usually at 125% of the current forward price than that of the long OTM option with the lower strike price.

Additionally, it involves the put option spread, which includes the sale of a put option with a strike price usually at 80% of the forward price and the purchase of a second put with a lower strike price which is usually at 65% of the forward curve. The combination of the two call options provides a hedge against rising fuel prices but only up to certain extent. Gains from rising fuel prices above the lower strike price are capped by the higher strike short call option position. On the other hand, the combination of the two put options allows the company to offset the cost of the call option spread and limits any exposure to potentially declining fuel prices.

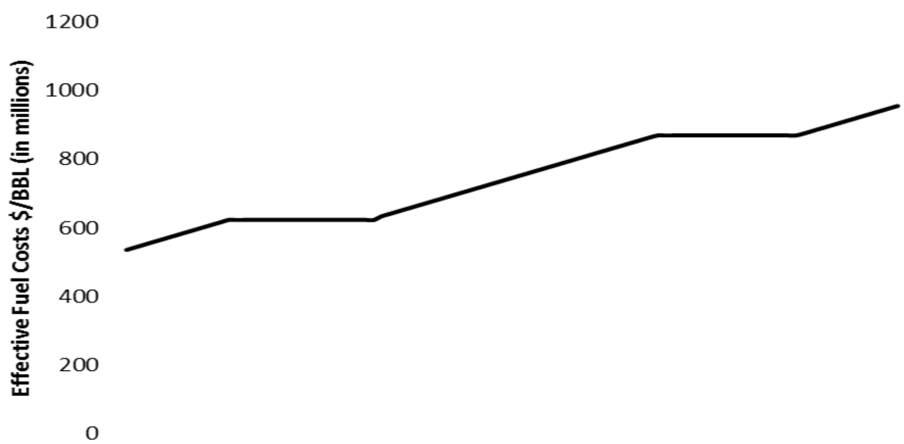

Figure 4: Pay-off Structure of a 4-Way Collar Strategy for 2006

3.3.4.4. Participating Collars

In the case of a participating collar, a company normally sells one ATM option and buys an OTM option on the same maturity and underlying. For commodity end-users, the strategy involves buying a call option struck OTM and selling a put option struck ATM. It is obvious that the premium due from the sold ATM put option will be larger than the purchased call option, in which case the option is identical to a premium collar strategy for energy producers.

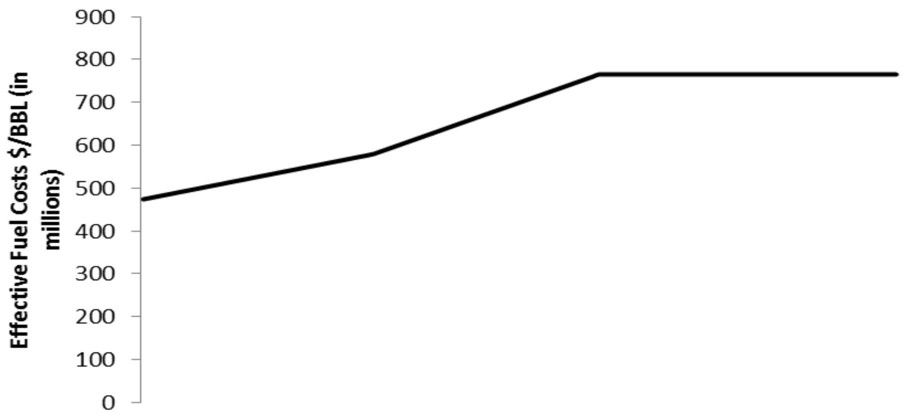

Figure 5: Pay-off Structure of Participating Collars for 2005

What makes participating collars different from normal and/or premium collars is the size of the option purchased is such that the total premium paid for the upward protection is equal to the premium received from a short ATM put option. In order to achieve zero cost structure, the size of the short ATM put option will be less than that of the long OTM call option.

The proportion of the size of the ATM option sold (a put option in this case) to the size of the OTM option bought (call option in this case) gives the participation rate. The participation rate represents the rate at which the hedger participates in favourable price moves in the collar structure. As an example, assume that an airline company want to hedge the risk of increasing fuel prices. Also assume that the company is cash conscious and doesn't want to pay significant amounts in premiums up front. As a result, the company decides to employ a costless collar strategy. However, the company also realize that there is a potential for falling prices and costless collars which would result in full exposure to falling jet fuel prices. So, the airline use a 50% participating collar structure where it would only be exposed to 50% of the price risk (resulting from a short put option position) should prices unexpectedly fall. In such a case, the airline company will be able to capture 50% of the benefits of decreasing prices while the strategy still offers 100% protection on the upside.

3.3.5. Turkish Airlines' Hedging Program

Table 12 presents operational data from the annual report of Turkish Airlines (THY) for the examined seven-year period, 2005 to 2011 all of which are collected from annual and quarterly financial reports of the company. It shows that fuel costs steadily increased alongside a significant increase in operational activity measured by available seat kilometres (ASK)[13] and revenue seat kilometres (RSK)[14] both presented in millions. During this period, fuel costs reached almost 34% of revenues (Fuel Margin) and operating expenses (Fuel/OPEX). In addition, Table 23 also shows operational expenses per passenger (OPEX/Passenger) and fuel costs per passenger (Fuel Cost/Passenger). These are the two operational breakeven measures, so in order to breakeven, THY must have operating revenues per passenger (EBIT/Passenger) that are greater than their operational expenses per passenger (OPEX/Passenger). Similarly, in order to breakeven, THY must obtain per passenger fuel costs (Fuel Cost/Passenger) that are lower than the estimated figures. For example, in order to breakeven for the year 2011, the company needed to obtain a Fuel Cost/Passenger ratio of less than $122. Both of these breakeven measures have been steadily increasing and reducing profit margins.

The motivation behind this study is the fact that Turkish Airlines had no hedging position until the year 2008 when the company decided to establish an Enterprise Risk Management project. The company states that its' commodity price risk management program aims to mitigate the effects of fuel price variations on jet fuel costs by fixing the cost of jet fuel within a specific band or at a single price, thus minimizing the consequences of adverse conditions that may arise in the fuel market. The risk management program intended to hedge 20% of the 2009 fuel consumption and is conducted on a staged basis which reduces the amount of fuel consumption hedged by 1%-2% each month up to 16 months ahead.

Fuel expenses were TRY1.8B in 2008 and TRY1.5B in 2009. However, the reduction in fuel expenses is not credited to the hedging program but to the reduction in spot oil prices falling from $147/bbl (per barrel) in July 2008 to $45/bbl in February 2009. Jet fuel prices were, on

[13] Number of total seats an airline company has in its fleet multiplied by the total kilometres flown.

[14] Number of total seats purchased multiplied by the total kilometres flown.

average, $52/mt (metric tonnes) cheaper in 2009 compared to 2008. The company states that the reduction in fuel costs attributable to risk hedging activities were just TRY0.004B, which is a significantly trivial amount. On the other hand, fuel costs increased by TRY0.3B due to increased consumption and decreased by TRY0.9B due to reductions in spot oil prices. One reason for the inefficiency of the risk management program could be that the company's stage based hedging used forwards which reduce the amount of jet fuel consumption hedged over the next 16 months. Oil prices started to increase sharply over the period and the company did not make any adjustments to its hedging program over the course of 2009. Although jet fuel prices averaged less than 2008, Turkish Airlines seem to have underhedged in 2009 despite increasing oil prices.

The hedging program for the year 2010 was not materially different from the hedging program in 2009. The company hedged 20% of its annual fuel consumption using the same stage based strategy and forward contracts where the percentage hedged decreases 1%-2% ever month for the next 16 months. In both 2009 and 2010, the hedging program locked in to $90/bbl oil prices. Again, fuel costs savings due to risk hedging activities were TRY0.005B for the year 2010 when the total fuel costs increased by TRY0.6B compared to fuel costs in 2009. The company reports that TRY0.275B of the TRY0.6B increase in fuel costs were related to increased consumption. However, TRY0.35B of the increase in fuel costs is related to increases in oil prices - equivalent to 58% of the total increase in their fuel bill. This indicates that hedging failed to offset the majority of the increase in fuel costs. This is likely to be the result of the fact that as in 2009, oil prices in 2010 were on an upward trend whereas Turkish Airlines decreased its hedging levels each month as part of a downward ladder hedging strategy.

For the first two years of the hedging program, the company preferred hedging that utilised linear pay-off forwards which provides upside protection should prices increase above the pre-agreed $90/bbl[15] fixed price level. This strategy works well when oil prices are trending higher but the company steadily reduces the amount of fuel consumption hedged through its

[15] The company actually managed to get $90/bbl fixed price for two consecutive years.

inverse ladder strategy (where the percentage of fuel consumption hedged decreases steadily) and doesn't dynamically adjust the hedging program amid new market information.

In 2011, the company increased its hedge level to 50% of fuel consumption switching the derivative instruments used from forwards to zero cost four-way collars. In a similar way to 2009 and 2010, the company applies an inverse ladder hedging strategy through which the percentage level of fuel consumption hedged decreases by 2%-3% each month for the next 24 months. The company has obtained a fixed price range somewhere around $90/bbl, similar to the previous 2 years. Since this is a zero cost 4-way collar, the pay-off structure of the hedging strategy is linear. Fuel costs increased from TRY2.2B in 2010 to TRY4.0B in 2011 of which TRY1.1B was due to increases in oil prices while only TRY0.5B was due to consumption. The risk hedging activities of 2011 worked completely at the expense of the company, contributing TRY0.1B to the total fuel cost expense. This means that the hedging program failed to offset the increase in fuel costs and also generated a loss.

The second element tests for the different jet fuel hedging strategies that Turkish Airlines could have used from 2005 to 2011 in hindsight. In order to conduct an ex-post case study, fuel consumption data is needed. The data for Turkish Airlines' fuel consumption is collected from the company's annual reports. Although Turkish Airlines provided the actual fuel consumption data (in gallons) after 2009, the ratio of fuel consumption-to-available seat kilometres (ASK, previously stable at 0.0029%) permits us to derive fuel consumption prior to 2009 using publicly available ASK data. From this information, an approximation of the amount of fuel consumed per year (est. Fuel Cons. in metric tons) can be obtained with the well-justified assumption that the "fuel costs as a percentage of ASK" have remained stable. Table 12 also provides information about fuel consumption, ASKs, kilometres flown and fuel expenses for the sample period from 2005 to 2011. The fuel consumption data is then used in estimating the results of each hedging strategy.

This study starts with an ex-post scenario analysis where prices move ± 50% around their median levels as observed in each year from 2005 to 2011. This provides a set of price observations with equally likely probabilities. This simulated data is used to calculate the "effective fuel costs" that could be obtained using each derivative instrument for both 50% and 100% hedge levels. The effective fuel cost, also described in essay 1, is calculated as follows:

$$EFC = Hedged\ \% \times Fixed\ Price + Non - Hedged\ \% \ \times Spot\ Prices$$

The wider the range between these upper and lower tail effective prices (FCaRs), the higher the volatility of the derivative position is expected to be. For example, Table 15 presents the results of upper tail Fuel Cost at Risk (FCaR) calculations for single derivative positions. Upper tail risk is calculated for each derivative instrument using 90% and 95% confidence intervals using a Monte Carlo simulation technique. For each year examined, Monte Carlo simulations generated 10,000 jet fuel price patterns which are dispersed ± 50% around median values observed each year. Next, these simulated price observations are used to estimate the effective fuel cost that could be obtained using each derivative instrument. To illustrate, for a 50% hedge the "effective fuel cost" is calculated so that;

$$EFC = \underbrace{\%50 \times Fixed\ Price}_{\textbf{Hedged Portion}} + \underbrace{50\% \ \times Spot\ Prices}_{\textbf{Unhedged Portion}}$$

The sum of the above equation will produce the effective fuel cost each hedging strategy generates. Depending on the pay-off structure of the hedging instrument, the cash flow stream of the "hedged portion" of the above equation will change. An unhedged portion for 50% hedges will be the same for each hedging strategy. In other words, it is the left hand side of the equation, the hedged portion, which will make the difference in cash flow streams from derivative positions. For 100% hedges, the right hand side of the formula (the unhedged portion) drops.

Next, the effective fuel costs obtained are compared to a "benchmark" strategy where the airline company doesn't hedge, which has been the case for the majority of the last decade for Turkish Airlines. The bottom row of each panel presents the total cost savings that could have been achieved using each derivative instrument for both 50% and 100% hedge levels. These fuel cost savings include the total cost of establishing hedging positions for both 50% and 100% hedges. The same calculation procedure is used for the combination strategies in Table 14.

Once generated, the simulated data and calculated effective fuel costs can be obtained using each hedging strategy and level. The next task is to define the risk exposure of each hedging strategy meaningfully and also define a "benchmark" strategy where an airline company doesn't hedge. The measure for the risk exposure is the "Fuel Cost at Risk", a measure that is exactly the same as "Value at Risk". Value at Risk (VaR) measures the maximum amount that can be lost in a defined period of time (usually a day) as a result of risk factors with a given degree of statistical confidence, for example 90%. FCaR applies the same measure of risk to the effective fuel costs estimated for each hedging strategy. More precisely, it calculates 1) the highest fuel cost that could be achieved and 2) the lowest fuel cost that could be achieved for each hedging instrument with degrees of statistical confidence (90% and 95% in this case)

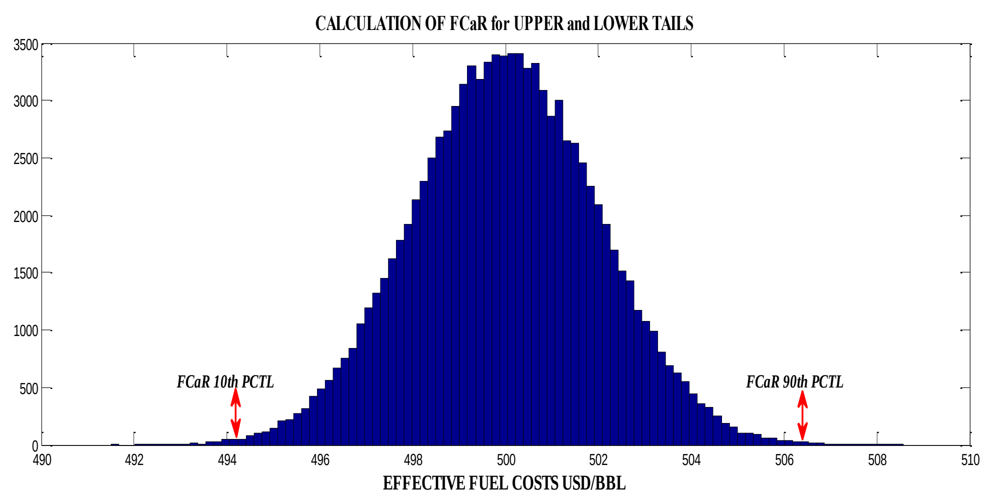

Figure 6: The Distribution of Effective Fuel Costs for 2005

Figure 6, above, visually demonstrates the calculation of FCaR using effective fuel costs obtained from the simulations of jet fuel prices in 2005. For Asian options, the 10th percentile in the effective fuel costs distribution in the left tail is \$316.7M and is the lowest possible total fuel cost obtainable using a 90% confidence level. The 90th percentile in the effective fuel costs distribution in the right tail is $417.4M and is the highest possible total fuel cost obtainable using a 90% confidence level.

Next, "hedging efficiency" (HE from here on), which is $\left(\frac{Fuel\ Costs\ Saved}{FCaR}\right)$, is estimated for both the upper tail and lower tail FCaR measures used in order to compare the risk and benefit profiles of each derivative instrument. The higher the ratio of "Fuel Costs Saved-to-FCaR" is, the more efficient the hedging is; and the higher the benefits of a derivative position are given its risk profile, the greater the HE ratio is. The standard deviation of the HE ratio is estimated in order to measure the variability in the efficiency of a given derivative instrument. As Parsons and Mello (2000) state, the optimum hedging strategy is the strategy that doesn't expose the hedger to any additional significant volatility.

First, single positions in derivative instruments are examined including swaps, Asian options, collar strategy, participating collar and four-way collars. Each instrument is compared in terms of their ability to benefit the airline company with potential fuel cost savings taking into account the cost of obtaining the derivative positions and the position-wide risk exposure (volatility inherent in the derivative position). Next, combination strategies between non-linear-pay-off options and option strategies and linear-pay-off plain vanilla swaps are examined in order to test whether the hedging portfolio can be "fine-tuned" using non-linear instruments. The criteria of "fine-tuning" the existing swap positions examines whether the inclusion of non-linear instruments has any additional contribution to make to the amount of fuel costs that could be saved, or reduction in the variability of the pay-off structure of the hedging positions, taking into account the costs of obtaining these combination positions and risks. The same risk-benefit analysis is conducted for the single derivative positions using FCaR and the variability of the HE in the combination strategies.

3.4. Hedging with Futures and Options: The Role of Implied Volatility

NYMEX monthly futures contracts (product symbol CL) and NYMEX option contracts on futures (product symbol LO) on WTI crude oil from January 2006 to December 2012 are obtained from Bloomberg. The scope of the analysis is limited to this period as the implied volatility data is only available after January the 1st, 2006. Similarly Bloomberg provides the IVs for each derivative contract for the same time period. Bloomberg computes the IV for each maturity and strike level equating the Black-Scholes formula to the actual option prices. They provide three levels of IV. First is the IV calculated from the sigma calculated as:

$$Sigma = \frac{ln\left(\frac{K}{F_{IMP}}\right)}{\sigma_K \sqrt{T}} \qquad 3.4.1$$

The second IV function is based on the moneyness of the options such as it being at-the-money. The surface of the IV which represents volatilities for different maturities and strike levels are normalized by the moneyness. Moneyness is measured as:

$$\%Moneyness = {}^{Strike\ Level}/_{Spot\ Price} \qquad 3.4.2$$

The third IV function is the delta-neutral measure. This method is perceived as the most accurate way to analyse historical behaviour of a particular option with a given delta.

$$Delta = \frac{ln\left(\frac{F}{K}\right)+\frac{1}{2}\sigma_k^2 T}{\sigma_K \sqrt{T}} \qquad 3.4.3$$

There are several differences between the “Delta Neutralized” volatility surface and the Moneyness volatility surface. First of all “Delta Neutralized” IV surface provides more detailed volatility data in the at-the-money range. Second, while Moneyness surface provides IV for each fixed level of moneyness along with a delta, “Delta Neutralized” IV surface provides an IV for each fixed delta along the moneyness. As a result, “Delta Neutralized” IVs are used in the calculations.

Both futures and options on WTI crude oil is for 1000 barrels with a minimum fluctuation of $0.01 per barrel and extends 9 years forward. Futures contracts are for physical delivery but in 99% of the cases, contracts settle before delivery. This is mainly due to the fact that standardized contracts traded in the exchanges include maturity, quality and quantity basis and hedgers prefer to use cash settlements. For the analysis, the exposure is assumed to be long 100,000 barrels of crude per month, which means that 100 contracts of either futures or options are bought every consecutive month.

Accordingly, two strategies are tested: The first strategy, the benchmark strategy, is the simple roll-over hedging where each month, 2 days before the settlement date, the contract is closed while a contract in next month futures is simultaneously established. For example, the January risk exposure is hedged using a February contract and the February risk exposure is hedged using a March contract. One limitation here is that contracts might be closed and/or rolled over before the 2-day period applied in this study. However, a 2-day measure is used as standard by Hull (2008) and followed in this study. Accordingly, if the one-month-ahead, implied volatility of the far out-of-money put option is higher than the implied volatility of the far out-of-money put option of the *current* month, then the market sentiment is bullish on oil prices and the use of non-linear pay-off futures options is preferred.

The second strategy uses the predictive power of the IV function. We use the change in the implied volatilities of the two concurrent contract months, where the first contract is the current contract to expire and the second contract is the next to expire. For example, in January 2006, the contract available to hedge is the March 2006 contract and the next to expire is the May 2006 contract. When the difference between the IVs of the far OTM put options between the May 2006 contract and the March 2006 contract is positive, this indicates a bearish sentiment in which investors are positioning themselves in far OTM put options as an insurance against a price decline. As a result, options are preferred as a result of the increased probability of price declines. Option instruments would allow the hedger to benefit from lower market prices should the price of the underlying fall below the strike price. The maximum value at loss is the option premium paid. Table 23 demonstrates the changes in the IVs of the concurrent contracts and the instrument choice based on the above mentioned criteria. The number of future contracts vs. option contracts signalled by the IVF is nearly balanced where in 55% of the cases, the IVF function indicates to use futures and 45% of the cases options.

3.5. Summary

This section provided detailed information on the data collection process and pricing and regression models used in all three elements of the thesis. The first element of the thesis relies significantly on hand-collected data on the quantitative information of hedging data. It is never enough to stress out the importance of using quantitative (continuous) hedging data rather than a qualitative (dichotomous) hedging data. Although qualitative data yields greater firm-year observations the data is not near the quality of information that continuous hedging data contains. For example, the use of qualitative data results in 476 firm-year observations in the Appendix 3 of this thesis. However, qualitative data doesn't distinguish 1% hedging from 90% hedging which makes a great difference both economically and statistically. Since the quality of the data directly impacts the results of the regressions this thesis uses dichotomous hedging variables in Appendix 3 as robustness check.

The selection criteria also avoids using airline company data for regional carriers and cargo carriers which have significantly different business models that allow them to access to a number of operational hedging measures that low cost carriers and major carriers do not have access to. This is the pitfall that this thesis shows that Carter et al. (2006) study has fallen.

The second element of the thesis use Turkish Airlines as a case study firm which remained significantly unhedged for the majority of the sample period examined. It is important to select a company that did not hedge for the purposes of this study as the focus is on to compare hedging to non-hedging scenarios. This is the first difference from Gerner and Ronn (2012) who asks similar questions to ours but using an already hedging airline company data. On the other hand, the data in this section is used to price the most-used derivative products in the commodity risk management while Gerner and Ronn (2012) study is limited to Asian options.

The third element of the thesis use delta-neutral implied volatility data from Bloomberg. The earliest available implied volatility data starts from 2006 in Bloomberg database. It is acknowledged that implied volatilities have significant time series features that might increase the dependency of the results to the time period examined. This is regarded as one of the limitations of the analysis.

4. RESULTS

4.1. Introduction

Section 4.2.1 presents the results of univariate analyses. These analyses compare the control variables and the test variable, percentage of next year's total fuel consumption hedged, of 1) hedging and non-hedging firm years, 2) LCCs and MCs, 3) airline companies with government ownership and privately owned airlines and 4) MCs with government ownership to MCs with no government ownership. The aim of these univariate tests is to reveal the differences among different sub-samples which will help interpret the multivariate regressions with greater degree of confidence.

Section 4.2.2 conducts series of multivariate regressions to test the value relevance of hedging. This section also performs a number of robustness-check regressions using carefully chosen variables to control for endogeneity and omitted variable bias. Section 4.3 tests for the hedging efficiency of swaps, Asian options, collars, participating collars, four-way collars and combination of these strategies. All the analyses use the fuel consumption data of Turkish Airlines which are then compared to non-hedging (benchmark) scenario and the actual operational and financial results of Turkish Airlines. Section 4.4 tests for the information content of the IVF and its potential use on the determination of optimum derivative instrument.

4.2. Hedging and Firm Value

4.2.1. Univariate Analyses

The fundamental underlying of hedging, alongside theoretically documented incentives, is to facilitate the timely delivery of forecast level of cash flows. Although it is not possible to eliminate all the risks of future cash flows, those related to hedgeable risk factors are manageable using financial instruments. Hedging can be referred to as a “success” if it helps reduce the undesired level of volatility in cash flows. If the target level of variability in cash flows is assured, management can focus on its core operations more efficiently. Hence, this section begins by testing if hedging is useful in lowering variability in internal cash flows.

Panel A of Table 2 conducts univariate analysis for hedging and non-hedging firm-year observations and reports mean and median level differences as well as the standard deviations for each dependent and control variable (both adjusted and unadjusted) for hedging and non-hedging-year observations. The mean and median values of control variables are similar for both sub-samples except for the level of fuel costs as a percentage of total operating expenses (Fuel/Opex) and leverage (both unadjusted and adjusted for off-balance sheet leases). The results indicate that, on average, hedging firm years coincide with 6% lower fuel costs-to-total operating expenses compared to non-hedging firm-year observations. Similarly, the median (Fuel/Opex (med.)) ratio is 2% lower for hedging firm year observations compared to non-hedging firm year observations.

Additionally, hedging-year observations are associated with 4% lower variability in operating cash flows σ (CFO/Rev) and 6% lower variability in capital expenditures σ (Capex/Rev), both scaled by revenues, compared to non-hedging firm year observations. Non-hedging firms/years tend to utilize significantly more financial leverage compared to hedging firms/years. However, the sustainability of heavy reliance on external financing of investments and/or day-to-day operations in the extremely concentrated, low-margin environment of the airline industry is questionable.[16]

The analysis in Panel B of Table 2 is a univariate test of control variables for both the low-cost and major airline subsamples. It demonstrates statistically significant differences in firm value, measured by both unadjusted (UAQ) and adjusted Tobin's Q (Adj.Q); the level of investment opportunities measured by Capex-to-revenues (Capex/Rev); the level of operating cash flows measured by cash flows from operations scaled by revenues (CFO/Rev); and profitability measured by both unadjusted (RoA) and adjusted return on assets (RoA Adj.).

The results in Panel B of Table 2 demonstrate the superior performance of the low cost carrier business model over the major carrier business model for the sample period examined. LCCs have significantly greater capital expenditures, cash flows from operations, and return on assets for the low-cost sub-sample, indicating higher growth expectations compared to the major airlines. Additionally, the major carriers have utilized significantly more external financing compared to the low-cost carriers. Whether these observations are attributable to capital budgeting policy or to limited access to external financing for the latter, or both, it suggests that as high growth firms, low-cost carriers can be more sensitive to the level of internal cash funds. This is observable from Figure 9 which shows that LCCs have significantly greater portion of cash-to-total assets ratio, lower leverage compared to MC. In addition, Figure 10 shows that LCCs preserve greater portion of their earnings compared to MCs. Consequently, the deficiency of internally generated cash flows might expose low cost carriers to significant underinvestment problems. This argument is analysed in greater detail using multivariate analyses in section 4.2.2.

In addition, regressions in Panel C tests for the effect of one period lagged percentage of the next year's consumption hedged on the level of fuel costs scaled by total operating expenses. The one year lagged hedge variable is used as an independent variable in order to better reflect the timely impact of the hedging decision that is made in year $t-1$ and the results

[16] Only in the U.S. 190 airline companies filed for chapter 11 bankruptcy since 1990, the most recent ones being American Airlines (2011) and Pinnacle Airlines (2013).

from actual hedging that materialized in year t. In the airline industry, fuel is a nonfinancial asset and is reported as the "net effective fuel cost" (i.e., the difference between actual jet fuel costs on the spot market including taxes, less (plus) any gain (loss) from the hedging transactions). As a result, any financial impact from hedging transactions at time $t-1$ will be recognized in fuel cost expenses at time t. So, the following equation is tested:

$$FCosts/OPEX_{(t)} = \alpha_0 + \beta_1 Hedge_{(t-1)} + \beta_2 FCosts_{(t)} + \varepsilon \qquad 4.2.1$$

The results show that the ratio of fuel costs to operating expenses at time t is significant and negatively associated with the hedging percentage entered into at time $t-1$, and significant and positively associated with jet fuel prices at time t. Given the accounting requirements of IAS39 and the U.S. equivalent SFAS133, we interpret these results as evidence that hedging reduces fuel costs.

The deregulation of the airline industry outside of the U.S. (U.S. deregulation occurred in 1978) came in rather gradually largely because governments put their national interests before operational efficiency. Although aviation markets are more efficient compared to 20 years ago, there still remains a degree of government intervention within the management of some of the major carriers or so called "*flagship* carriers". About 40% of the airline companies in the major carriers sample have government ownership at or above 20% of the total shares outstanding (see Appendix 2), which theoretically can exert significant influence over planning and budgeting decisions. It can be argued that these airline companies might enjoy a degree of competitive protectionism and financial support from their governments that might make them less risk averse than privately owned airline companies.

Univariate analysis in Panel A of Table 3 compares airline companies with government ownership to privately owned airline companies. Privately owned airline companies include all of the low cost airlines in addition to major airlines with no government ownership. The analysis in Panel B of Table 3 compares major carriers with government ownership to major carriers with no government ownership.

Both panels show higher firm value for airline companies with no government ownership. Expectedly, in both panels, major carriers with significant government ownership hedge a significantly lower amount of their total expected fuel consumption compared to airline companies with no government ownership. It can be argued that the differences in hedging behaviour might be a result of the comfort of having financial support from governments (*too big to fail*) and/or a lack of effective risk management policies.[17] These results should not necessarily suggest a positive association between hedging and firm value for these privately owned airline companies. Univariate tests in Panels A and B in Table 3 is not a direct examination of hedging and firm value relationship. Higher firm values for privately owned airline companies might be a result of differences in operational efficiency other than hedging, which we cannot capture with univariate tests. Consequently, the next section also controls for government ownership in the multivariate regression analyses.

4.2.2. Value-Additive Proposal

Panels A and B of Table 4 present the results of regression analyses testing for the association between hedging and firm value for the low-cost carriers, and major airlines. The model that we test is:

$$\boldsymbol{Ln\,Q = \alpha_0 + \beta_1 Control\,Variables + \beta_2 Hedging + \varepsilon} \quad (4.2.2)$$

The dependent variable, $Ln\,Q$, is the natural logarithm of the unadjusted and adjusted Tobin's Q. The independent control variables used are 1) Log (assets), 2) Leverage, 3) RoA (return on assets), 4) Capex/Rev (capital expenditures scaled by revenues), 5) CFO/Rev (cash flow from operations scaled by revenues, 6) Dividends, 7) HIR (interest rate hedging

[17] Despite being privately owned, some airline companies still receive government support. This is usually the case if the airline in question is a national carrier (flag carrier) of a country. An example of such an arrangement has been Japanese Airlines (JAL) which received ¥350B from Japanese government during a re-structuring period in 2010. We are unable to capture the majority of similar implicit government/carrier relationships as information on government subsidies is not usually publicized. Additionally, the degree of government support for these national carriers might not necessarily be in the form of a net cash infusion but rather in the form of easier access to external capital through state owned borrowing channels.

dummy), 8) HFX (foreign currency hedging dummy) and 9) Time dummy as previously suggested and used in corporate risk management (Allayannis and Weston, 2001; Carter et al., 2006; Jin and Jorion, 2006).[18]

Panels A and B of Table 4 present regression results using unadjusted and adjusted Tobin's Q as a dependent variable and hedging as a test variable alongside control variables. Columns 2 and 3 show the results of our estimations for the low-cost carriers sub-sample (LCC), and columns 4 and 5 show the results for the major carriers sub-sample (MC). In all regressions, ordinary least squares (OLS R.) and generalized least squares regressions (GLS. R) both with heteroskedastically adjusted standard errors are used. The analyses indicate a significant and positive association between hedging and firm value for the low-cost carriers. The results in Panel B use adjusted Tobin's Q as a dependent variable and are robust to firm value, firm size, firm leverage and profitability control variables adjusted for off-balance sheet leases in all of the regressions. However, there is no statistically significant relation between firm value and the percentage of fuel consumption hedged for major airlines.

Panels A and B of Table 5 tackle the potential issues of endogeneity, particularly an omitted variable bias which may influence the hedging premium for the low cost carrier sub-sample. Following Allayannis and Weston (2001), in columns 2 and 3 in Panel A, a first-differenced data regression is conducted on the hedging variable and firm value where the dependent variable in column 3 is the adjusted Tobin's Q. The analyses examine whether the value premium from hedging is driven by actual changes in the levels of hedging, enabling to control for potential omitted variable bias. Results indicate that for both unadjusted and adjusted Q measures, hedging is a robust contributor to firm value for the low cost carriers sub-sample.

In the analysis reported in columns 4 and 5 in Panel A of Table 5, we use quantile regressions to control for the influence of possible outliers. For the analysis in column 4, with an unadjusted Q measure as the dependent variable, the positive association between hedging

[18] Neither interest rate nor currency hedging dummy variable provide information as to the level of hedges in our analysis. Unfortunately, using dummy variables to control for these hedges, we assume that 5% hedging has the same economical substance as 90% hedging.

and firm value is slightly outside the usual significance levels. In column 5, our analysis is robust at p=0.05.

Next, columns 2 and 3 in Panel B of Table 5 conduct fixed effect regressions using both unadjusted and adjusted Tobin's Q as a dependent variable respectively. The results in both columns indicate that the association between hedging and firm value remains robust in the face of a potential omitted variable bias for the low cost carriers sub-sample. Additionally, columns 4 and 5 allow for a correlation within each group of observations (airline companies) using cluster analysis. Relaxing the assumption of independent observations in both regressions provides the same positive results for hedging and firm value for the low cost carriers sub-sample.

Columns 2 to 5 in Panel C of Table 5 present the results of the instrumental variable analysis for LCC and MC sub-samples. The instrumental variable regression includes variables which are correlated with the hedging decision and are expected to influence our independent variable, log of Tobin's Q, only through its association with hedging. The literature on corporate hedging suggests potential variables that could be suitable as instrumental variables.

The first instrumental variable is the availability of managerial stock options indicated using dummy variables. As suggested by Smith and Stulz (1985), when management cannot diversify their personal wealth away from firm-specific factors and a large portion of the management's wealth is tied to the firm value, management is more likely to hedge those risks. Managers with stock options, however, are given greater financial flexibility and might be less risk averse. These arguments are supported empirically by the work of Tufano (1996).
The second instrumental variable is the expected oil prices obtained from the Reuters Oil Poll. Empirical evidence on corporate hedging suggests that managers input their personal view on future prices which in turn affect their hedging decision. This is called "selective hedging" and is supported by Adam (2003), Brown and Khokher (2005), Brown, Crabb and Haushalter (2005) and Faulkender (2005) among others. In line with the empirical evidence

we use one year ahead expected oil prices obtained from “Annual Energy Outlook” and published by U.S. Energy Information Administration as the next instrumental variable.

The third instrument used is the ratio of off-balance sheet leases to total assets. The use of off-balance sheet leases is common in the airline industry and is a proxy for the level of investment opportunities. An underinvestment framework, suggested by Froot et al. (1993), holds that under costly external financing, firms aim to align the maturity mismatch between internal cash flows and investment spending. Hedging is beneficial to the extent that it protects internal cash margins. Parallel to the underinvestment theory, is the expectation that firms with a higher ratio of off-balance sheet leases as a percentage of total assets (greater investment opportunities) are more likely to hedge their jet fuel exposures than firms with a lower ratio.

The fourth and final instrument used is the proportion of rival airline companies hedging out of the total number of rival airline companies. The identification of rival airline companies is limited to the airlines operating in the same region as the information about routes is largely company specific. In line with Nain (2004), it is expected that firms may have a higher propensity to hedge their jet fuel exposures if the majority of their competitor airline companies hedge. Column 2 and 3 show that, hedging, when used as an endogenous predictor of firm value, is robust to instrumental variable analyses for both LCC and MC sub-samples. Both Sargan (1958) and Basmann’s (1960) chi-square tests are insignificant, indicating that the endogenous variable doesn’t suffer from over-identification.

Panels A and B of Table 6 test for the categorical variable bias. Columns 2 to 5 use a low cost carrier dummy variable (LCCdummy), alongside its interaction (hedgeLCC) with the test variable; hedging, for the total sample using unadjusted and adjusted firm value and control variables respectively. In these analyses, we aim to test whether the positive results for hedging variable and firm value for the low cost carriers are robust to hidden “low cost carrier” firm bias. More precisely, the question asked is whether the prior results were driven by unobservable (and hence uncontrolled) characteristics of the low cost carriers (managerial abilities etc.). If the direct positive relation between hedging variable and firm value is genuine, then the coefficient between the interaction variable (hedgeLCC) and firm value should be positive regardless of the coefficient between the low cost carrier dummy variable (LCCdummy) and the firm value. Using heteroskedasticity adjusted ordinary least squares regression (OLS R.) and generalized least square regression (GLS. R.), with robust standard errors, all of the regressions demonstrate a positive association between the interaction variable (HedgeLCC) and firm value regardless of the coefficient for low cost carrier categorical variable (LCCdummy). These results indicate that the association between fuel hedging and firm value is robust to a possible low cost carrier firm bias.

The analyses in Panel B of Table 6 divide the sample into U.S., European, and international subsamples and assign an $n-1$ dummy variables (USdummy for U.S. firms and EUdummy for E.U. firms and use international sample as base) to control for the potential influence of differences in location. Additionally, $n-1$ interaction variables are used to (HedgeUS and HedgeEU for U.S. and European firms, respectively) control for the next year's fuel consumption hedged by airline companies from both regions. This is important since global airline companies are subject to different accounting regulations and industry specific characteristics which could not be controlled for.[19] The panel performs heteroskedasticity adjusted ordinary least squares regressions (OLS R.) and generalized least square regressions (GLS. R.), with robust standard errors in all regressions for both unadjusted and adjusted firm value and control variables. The results in all columns indicate that the relationship between hedging and firm value is robust to low cost carrier hedging interaction variable indicating that there is no significant regional level outlier that affects our results.

Finally, Table 7 examines whether government ownership has an influence on our results. The relation between hedging and firm value for the low cost carrier sample might be driven by the relatively poor financial performance of the major carriers with government ownership. If this is the case, it is expected to observe a positive firm value and hedging relation for privately owned major carriers. In this context, in all columns, a dummy variable (GOVdummy) is added, which takes the value of 1 if the government ownership is at or more

[19] These include the ability to transfer a specific portion fuel costs on to customers, managerial abilities, investors risk aversion etc. which might vary depending on the region.

than 20% of the total number of outstanding shares and a variable (hedgeGOV) is added to represent the interaction between government ownership and hedging. Columns 2 and 3 conduct categorical variable regression analysis on the unadjusted data for the major carriers sub-sample and columns 4 and 5 conduct categorical variable regression analysis on the adjusted data for the major carriers sub-sample. Both ordinary least squares (OLS R.) and generalized least squares (GLS R.) regressions use heteroskedasticity adjusted robust standard errors.

The results in all columns indicate significantly lower firm values for airline companies with government ownership. This is in line with expectations stated in the introduction of this thesis. However, the interaction variable (hedgeGOV) presents no statistical relation between firm value and hedging for these airlines in any of the regressions. The hedging coefficient for major carriers is insensitive to the government ownership control variable. These findings suggest that the results for the low cost carriers might be driven by the investors' appreciation of greater growth potential and relatively higher sensitivity to internal cash funds for low cost carriers' business model and as a result, the need for fuel risk management to assure an orderly cash flow stream. Based on a 32% average level of hedging for the low cost carrier sub-sample and using the results of unadjusted regressions, the average coefficients for hedging test variable correspond to a value premium of 5% to 8% of the mean market value on average.

As part of one of the limitations of this thesis, this study cannot analyse the interaction between operational hedging using fuel surcharges and financial hedging due to data constraints. This data is unique and very hard to obtain but may enclose a number of economically and statistically important properties that might help us better understand the coordination between operational and financial hedging.

4.3. Hedging Effectiveness and Derivative Instrument Choice

This section compares the results of derivative instruments used in the scenario-based hedging program to 1) a non-hedging benchmark strategy and 2) the Turkish Airlines' hedging program.

Panels A and B of Table 13 present, in millions, the results of fuel cost savings for each hedging instrument used. This table doesn't include combination strategies. The first column shows the years examined. Two strategies are used for each instrument: one applies 50% hedging and 50% spot purchase and the other applies 100% hedging. Fuel cost savings are estimated by comparing the effective fuel costs obtained for each hedging instrument to a "benchmark" zero-hedging strategy. The tables also show the cost of obtaining each different derivative position which is included in the calculation of fuel cost savings. Panels A and B of Table 14 exhibit the same analysis using combinations of plain vanilla swaps and non-linear instruments. The bottom rows in each panel of both tables show the total amount of savings achieved using each strategy.

Panels A and B of Table 15 and 16 present the upper tail estimates of FCaR analysis at 10% and 5% significance levels for each single derivative position as well as combination strategies. The bottom rows in each panel of each table present the sum of total fuel cost at risk for the seven-year period examined. Similarly, panels A and B of Table 17 and Table 18 conduct the same analysis for the estimates of lower tail effective fuel costs using 10% and 5% significance level FCaR analysis for single derivative positions and combination strategies.

Next, panels A and B of Table 19 calculate the HE ratio for each single derivative position and combination strategies using upper tail estimates of FCaR. Finally, panels A and B of Table 20 and Table 21 calculate the HE ratio for each single derivative position and combination strategies using lower tail estimates of FCaR. The bottom three rows in each table present the mean, median and standard deviation of HE estimates for each hedging strategy.

Panel A of Table 22 presents the total effective fuel costs that each instrument provides. Panel B of Table 22 summarizes the total amount of fuel costs that could be saved using each derivative instrument compared to Turkish Airlines' non-hedging strategy. Columns 2 to 8 show fuel costs saved per year and column 9 presents the aggregate fuel cost savings. Table 23 provides operational efficiency and profitability measures obtained from the annual reports of Turkish Airlines. Table 24 adjusts Table 23 based on panel A of Table 22 in order to compare the hedging strategies to the strategies Turkish Airlines followed.

4.3.1. Swaps:

Swaps worked particularly well in reducing the effective fuel costs in all of the observed years except for 2010. If used from 2005 to 2011, one-year maturity monthly average pay swaps could have saved the airline $416.4M and $832.8M in their total fuel expenses for 50% and 100% hedge ratios.

It is acknowledged as one of the limitations of this study that the fixed swap rate estimated here is very likely to be different from the actual swap rate the airline company in question could have obtained from the OTC energy markets. However, the shapes of the built forward curves in each year exactly match the shapes of the actual market forward curves. The difference between the actual OTC swap prices and swap prices will be the result of the curvature of the forward curve which includes the market-determined prices for different maturities. One of the reasons why swaps have been successful in jet fuel risk management could be the result of this difference between the actual swap prices and our model swap prices.

In practice, there are numerous forward curve building models, from simple one factor models to complex three factor models, and all of them aim to serve a different energy product or commodity and the maturity structure. Additionally, there is a very efficient OTC market where market makers set the prices depending on demand and supply conditions for different maturities.

Swaps are zero cost instruments with a pre-agreed fixed price for pay fixed receive floating (typical for an airline hedger). Panel A of Table 8 demonstrates the FCaR analysis for Swaps. Compared to other derivative instruments, the swaps in our sample could have provided the airline the lowest possible maximum effective fuel costs followed by Asian options. However, panel A of Table 17 shows that swaps did not provide the lowest possible minimum effective fuel costs. The lowest possible minimum effective fuel costs are obtained using four-way collars followed by Asian options and participating collars which provide non-linear pay-off structures as opposed to swaps. Panel A of Tables 19 and 20 shows that the mean HE ratio is 12% with a standard deviation of 10% for both the upper tail and lower tail FCaR in the denominator. Both the mean HE ratio and the standard deviation of the HE are the highest for the swaps. This is not surprising for two reasons: Oil prices have been on a rising trend since the early 2000s apart from an exceptionally volatile period in 2008 (see Figure 11). As a result, swap instruments with zero upfront costs could have provided effective protection for the upside price movements. Of all the derivative instruments and combination strategies examined, swaps could have saved the highest USD amount of fuel expenses, which is a positive contributor to HE ratio.

However, due to its symmetrical pay-off structure, swaps expose firms to additional volatility in cash flows when the underlying prices swing in a band and not trend upwards (for pay fixed receive floating swaps). The higher the volatility in prices, the more cash flow volatility inherent in the swap positions. Panels A and B in Tables 19 and 20 show that although swap instruments provided the highest benefit-risk combination, they are also the most volatile in terms of cash flow stream in our analysis. Moreover, since the price levels are fixed and the pay-off structure is symmetrical, these instruments could have made the airline company worse-off with possibly higher effective fuel costs (otherwise obtainable using non-linear pay-off instruments) if the jet fuel prices had fallen below the swap prices.

4.3.2. Asian Options:

Asian type monthly average pay options are very popular in energy risk management applications. The average pay features of these options smooth the volatility of the underlying (jet fuel prices in our case) and are usually cheaper than their plain vanilla counterparties.

Additionally, the monthly average pay features of these instruments provide a better match between the actual spot price jet fuel exposure and cash flows from derivatives positions. Table 11 presents the strike prices and corresponding premiums using different pricing methodologies, mentioned in the Data and Methodology section, alongside with the convenience yield estimated for the Asian options. For the Turkish Airlines' case study, the average price Asian options calculated using Monte Carlos simulations are used.

Panel A of Table 13 shows that Asian options could have saved the airline company $266.4M and $532.9M net of premium costs for 50% and 100% hedge ratios, respectively. The total premium paid to acquire these options was $264.4mn and $528.8M for $505M and 100% hedge ratios. The cost of insurance using Asian options has been particularly expensive since 2008 and reached $204.3mn in 2011.

Although it is assumed that the airline company is able to afford such high premiums, it is most likely be the case that management could choose not to hedge and/or hedge substantially less amounts or use collar strategies and/or linear pay-off forwards or swaps in order to reduce the cost of insurance.

Panel A of Table 15 demonstrates that Asian options provide the second lowest maximum effective fuel costs after swaps. Additionally, panel A of Table 17 shows that Asian options could have provided the second lowest minimum effective fuel costs after four-way collars. An asymmetrical pay-off structure of these options helps the airline company to take advantage of lower spot prices and only lose the premium paid.

The mean level of the HE ratio in panel A of Table 19 and panel B of Table 20 is between 8% and 11% for the upper tail FCaR and lower tail FCaR in the denominator. Similarly, the standard deviation of the HE ratio is 8% for the upper tail FCaR and 11% for the lower tail FCaR in the denominator. Any costly up-front premiums paid are likely to negate any potential fuel cost savings and increase the volatility of these instruments. Next, collar strategies which aim to reduce the cost of protection while preserving the flexibility of the non-linear pay-off structures are examined.

4.3.3. Collars

From the perspective of an airline company that is naturally short jet fuel, a collar strategy is established by going long on the call option and short on the put option. The premium received by the sale of the put option helps offset the premium paid for acquiring upside price protection. In some cases, the strike prices of each option are chosen so that the cash inflow from the sale of the put option completely offsets the cash outflow from the purchase of the call option. This type of collar structure is called a costless or zero-cost collar.

Following the guidelines mentioned in Gerner and Ronn (2012), collar strategies are designed as the combination of out of money (OTM from here on) call options with a strike price with 110% of the corresponding swap prices and OTM put options with strike price of 85% of the corresponding swap prices. The above strategy does not result in a zero cost collar structure.

Panel A in Table 13 shows that collar strategies could have saved the company $220M and $440M on average for 50% and 100% hedge ratios. These figures are very close to those of the Asian options with approximately only a quarter of the total premiums paid with $84mn and $167mn for 50% and 100% hedge ratios. The fuel cost at risk analysis in panels A of Table 15 and Table 17 demonstrates that collar structures managed to obtain upper and lower tail FCaR which are very close to the upper and lower tail FCaR estimated for the Asian options with a much lower up-front premium paid. Additionally, the variability in HE ratio is between 6% and 7%, which is significantly lower than Asian options indicating that the benefit-risk features these strategies could have provided were less volatile than that of Asian type options.

In the period examined, collar strategies worked relatively more efficiently when compared to Asian options. However, the risk-benefit structure (measured by the HE ratio) is entirely dependent on the strike prices of the two chosen options (long call and short put) which determines the range at which the airline company is comfortable enough to obtain spot prices and not fall into financial hardship as a result of insufficient operating cash flows.

4.3.4. Participating Collars

Participating collars, similar to collar strategies, provide the airline company with 100% protection for the upside price risk. However, participating collars enhance the flexibility of collar strategies by limiting the downside price exposure below the short put strike to the ratio of participation. Although it is not customary in practice, a 50% participation level is used which means that unlike the case of usual collar strategies, the airline company would be responsible for the short position in put options only to the extent of the participation ratio and not for the full amount. In order to achieve a 50% participation ratio, the amount of the put option sold in metric tonnes is equal to one half of the total fuel exposure hedged using long call options. Participating collars aim to choose the strike levels for each option in the structure in such a way that the premiums paid and received exactly match each other, generating a costless participating collar structure.

Panel B in Table 13 shows that participating collars could have saved the airline company $326M and $652M for 50% and 100% hedge ratios at zero cost. The USD amounts of fuel costs saved are the second highest after swaps. The advantage of the participating collar structures over swaps is that these instruments provide the flexibility to take advantage of lower prices which is reflected by cheaper total effective fuel costs obtained in lower tail FCaR analysis and obtained in the scenario analysis in panel B of Table 17. Panel A of Table 19 and panel B of Table 20 also show that in addition to lower possible effective fuel costs obtained, participating collars provide much smoother HE ratio with a standard deviation of 5% on average compared to swaps, Asian options and collar strategies.

4.3.5. Four-Way Collars:

A four-way collar is the combination of simultaneous purchase and the sale of two OTM call and put options. The inner collar structure has the same strike prices for call and put options as in the collar strategy where the long call option strike is set at 110% of the swap rate and the short put option strike is set at 85% of the swap rate. In addition to this inner collar structure, for the outer collar structure, the airline company sells a further OTM call with the strike set at 125% of the swap rate and buys a further OTM put option with the strike set at

65% of the swap rate. This is the industry standard convention mentioned in Gerner and Ronn (2012).

Four-way collars provide limited upside protection with limited downside exposure. The potential protection in the upside is limited by the short call, and the risk exposure in the downside is limited by the long put options. The range where the company obtains spot prices is somewhere between 110% OTM long call and 85% OTM short put options. Although the standard structure is used for consistency, different airline companies with different risk perspectives and market views could have established a very different collar structure.

Panel A in Table 13 demonstrates that a four-way collar strategy could have saved the airline company $185.5M and $370M for 50% and 100% hedges respectively. These fuel cost savings would come at a cost of $42.85M and $85.7M in premiums paid which forms a highly cost efficient strategy compared to single Asian options with premium costs of $264M and $528.8M for 50% and 100% hedge ratios respectively. These fuel cost savings, however, are less than those of collar and participating collar strategies.

The analysis in panel A of Table 19 and panel B of Table 20 shows that the mean HE ratio (Fuel costs saved as a percentage of fuel cost at risk (FCaR)), which measures the benefit-risk combination of the derivative positions, were 4% for the lower tail FCaR in the denominator and 8% for the upper tail FCaR in the denominator which is the lowest among all other derivative instruments and strategies. However, the variability in the HE ratio is between 2% and 6% for higher and lower tail risk exposures respectively. Interestingly, the analysis in panel B of Table 17 shows that four-way collars could have provided the lowest minimum effective fuel expenses among all other derivative instruments and strategies. However, panel B of Table 15 also shows that the maximum effective fuel expenses are also the highest for this strategy. The ideal situation for this strategy is to have lower price volatility. This would provide the hedger with effective fuel costs within the upper and lower range of the budgeted jet fuel prices.

4.3.6. Combinations:

Combination strategies test whether the inclusion of non-linear pay-off instruments would improve the results of linear pay-off swaps. The basic test combination is a 50% position in swaps and a 50% position in Asian option. The main reason why this combination is the most important to consider is due to the fact that combining symmetric pay-off swaps with asymmetric pay-off option strategies such as collars increases the downside risk of the portfolio and might turn speculative if the prices fall. Coupled with the symmetrical pay-off structure of swaps, the impact of such adverse price movements would be magnified by the fact that most of the strategies (collars and participating collars to a certain degree) would be accepting downside price risk to a certain extent. Despite the shortcomings, such strategies are also examined.

Panel A of Table 14 shows that the amount of fuel costs that could be saved using a combination strategy with equal positions in swaps and Asian options is $559M and would cost the airline company $264.8M as part of a premium paid for Asian options. Upper tail risk analysis in panel A of Table 16, which quantifies the maximum effective fuel costs the airline company might be exposed to, shows no improvement with the inclusion of Asian options to swaps. This is to be expected as both options and swaps provide the same degree of upside protection and the extra premium paid is for the flexibility provided by option strategies in the event of prices falling.

The lower tail risk analysis in panel A of Table 18 shows that the minimum effective fuel costs achievable have improved over a single swaps position. When an Asian option is included with a single swap position the amount of effective fuel costs was, on average, $955M lower compared to a single swap position. These potential fuel cost savings, which are greater than the total amount of premium paid ($264.8M), are the added benefit of holding non-linear pay-off Asian options in the hedge portfolio which enables the airline company to take advantage of lower fuel prices. The standard deviation of the hedge effectiveness ratio is between 8% and 10% which offers a slight improvement over single swap position.

4.3.7. Implications of Hedging Strategies for Turkish Airlines

Turkish Airlines remained unhedged in four of the seven years examined. The company started to hedge a minor 20% for the first two years before increasing hedging levels to 50%. Despite the increase in hedging level, the airline preferred to use an inverse ladder structure where the level of hedging gradually decreases with time. This structure, however, is not monitored against unfavourable price movements where prices increase while the level of hedging decreases. As discussed in section 3.2.4, Turkish Airlines's hedging program has provided no additional benefits in terms of fuel cost reduction due in no small part to unmonitored reverse-ladder hedging strategies.

The important question that this section aims to answer is whether hedging strategies that use different derivative instruments could have improved the operational margins and profitability of Turkish Airlines. The study uses static hedging of 50% and 100% of the total fuel consumption both for the sake of simplicity and comparison against the reverse-ladder strategy that Turkish Airlines applied. Panel A and Panel B of Table 22 present the effective fuel costs that could be obtained using each derivative instrument and the total fuel cost savings that could be achieved by Turkish Airlines. The results suggest that swaps could save the company TRY1.265B or USD886.6M for the seven-year period examined from 2005 to 2011 if 50% hedging is applied. For the 100% hedging fuel, cost savings reached TRY1.55B or USD1.09B in total.

Although swaps provided the highest level of fuel cost savings, cash flow stream of swap instruments is the most volatile compared to non-linear pay-off derivative instruments. Figure 7 (below) shows that fuel cost savings provided by swaps (50% hedging) fluctuate significantly compared to non-linear pay-off strategies which in turn increase firm level cash flow and the variability of earnings. Following swaps, participating collars could have provided TRY820M or USD565.7M for a 50% hedge and TRY1.28B or USD877M in fuel cost savings.

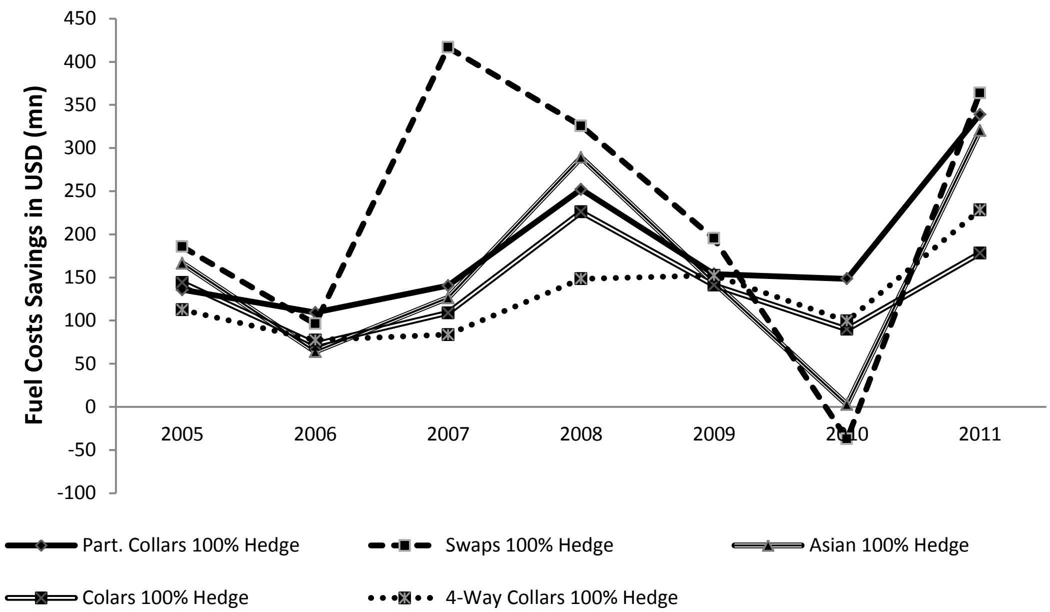

Figure 7: Fuel Cost Savings of Each Derivative Instrument

Asian options could have saved Turkish Airlines TRY731.4M or USD508.7M for a 50% hedge and TRY1.11B or USD772M in fuel expenses. Collar strategies could have saved Turkish Airlines TRY661M or USD462.5M for a 50% hedge and TRY960M or USD 670M in total. Four-Way collars could have saved Turkish Airlines TRY631M or USD434.6M for a 50% hedge and TRY901M or USD615M for a 100% hedge.

Table 23 presents the operational information regarding the cost structure of Turkish Airlines. The first column lists operational efficiency measures related to fuel consumption. The first measure is the cost per available seat kilometres (CASK), $\left(\frac{Operating\ Expenses}{ASK}\right)$, which demonstrates the proportion of operating expenses in terms of operational capacity. The next measure is fuel cost per available seat kilometres (FCASK),$\left(\frac{Fuel\ Expenses}{ASK}\right)$, which demonstrates the proportion of fuel expenses in terms of operational capacity. Both of these measures increased steadily over the time period examined. This was expected as the airline was in its growth stage during the time period. The proportion of fuel expenses in proportion to operating expenses,$\left(\frac{FCASK}{CASK}\right)$, have also been rising in line with the general trend in the airline industry. Following the operational efficiency measure, two profit measures are provided: net income and net margin $\left(\frac{Net\ Income}{Revenues}\right)$.

Table 24 presents the changes in operational and profitability measures presented in Table 23, should Turkish Airlines have applied the derivatives instruments studied. Only the results of 50% hedging and 50% spot purchases are presented for the sake of simplicity and for the fact that 100% hedges are extremely rare. The panels are ordered in terms of the amount of fuel costs saved. Panel A presents the results of swap instruments. Swaps have significantly improved operating costs, breakeven levels, OPEX/Passenger, Fuel Costs/Passenger, the proportion of fuel costs in total operating expenses, Fuel/OPEX and net margin. Panel B to Panel E present the results of non-linear derivative instruments. These instruments, despite saving less on fuel expenses in this particular case, provide a smoother earnings stream than swaps.

Overall, Turkish Airlines could have saved significant amounts in its fuel bill if the company had applied one or a combination of the derivative instruments examined. Although the company started hedging from 2008 onwards, the actual hedging benefits the company obtained from these hedges are infinitesimal. These results suggest that the instrument choice is critical in the success of a hedging program. For example, if the aim of a company is to minimize the variability in operating cash flows it can choose to use non-linear pay-off options or option strategies. Similarly, if the airline aims to both minimize the variability in operating cash flows and allow its fuel risk exposure fluctuate in a pre-defined price band in which it estimates reasonable probability of staying within budgetary targets, might choose four-way collars. On the other hand, the results of this study also highlight the importance of constant monitoring of the positions particularly when the hedge ratio is constantly decreasing with time as was the case with Turkish Airlines. Regardless of the type of a derivative instrument(s) used, the direction and the volatility of the jet fuel prices might debilitate the protection obtained from hedging if the airline company gradually leaves itself more exposed to price risks.

4.4. Hedging with Futures and Options: The Role of Implied Volatility

Table 26 demonstrates the results for the benchmark strategy where futures contracts are simply rolled over into the following month. The first column lists the contract months and the second column lists the position opening and closing dates. Column 3 and 4 shows the prices of futures contracts at the open and close of the contracts. Column 5 shows the size of the contracts which have fixed 100 long positions. Columns 6 and 7, calculated as; $\text{column } 3 \times \text{column } 5$ for column 6 and $\text{column } 4 \times \text{column } 5$ for column 7, show the notional amounts in USD millions for each position opened and closed. The final column shows the pay-off in USD millions for each position as the difference between columns six and seven. The simple roll-over strategy yields an average positive pay-off of $3.39M.

Table 27 displays the results of the IVF strategy. When the difference between the implied volatilities of the consecutive month and the next to expire far OTM put options is positive the IVF strategy suggests the use of futures contracts. Contrarily, when the difference between the implied volatilities of the consecutive month and the next to expire far OTM put options is negative, the IVF strategy suggests the use option instruments. Columns 1 and 2 show the contract month and size, respectively. Column 3 and 4 show the strike price and actual price at which positions are closed. Column 5 estimates the cost of opening option positions (premium per contract multiplied by the contract size). Column 6 and 7 show the pay-off from option and futures positions respectively. Column 7 displays the results of the IVF strategy. The pay-off is chosen from column 6 if the strategy suggests the use of options and from column 7 if the strategy suggests the use of futures. The first row of column 7 shows that the average pay-off from the IVF strategy is a loss of $9.40M.

These results indicate that, constructing a hedging strategy based on the predictive power of the IVF is not superior to a simple hedging strategy using futures. One could argue that the informativeness of the IVF may differ by the time series properties of various asset classes (i.e. commodities, equities, and currencies) and the results in this study might be the result of these dynamic properties of the IVF for different asset classes. One could also argue that the IVs themselves exhibit significant volatility. This, however, is not the case for the sample period examined. Column 5 in Table 25 show that regardless of the type of derivative instrument the IVF strategy suggests, the suggestion of that particular derivative instrument is likely to be clustered. That is, suggestion to use futures contracts is likely to be followed by suggestions to use future contracts. In that sense, the recommendations of the IVF strategy are stable and possibly predictable.

The decision to choose a specific type of derivative instrument is vitally important in any risk management program not only for commodity price risk management. Once the decision to hedge or not is made by the management the choice of instrument remains as the next challenge for the decision makers. The results of this study indicate that the market sentiment, measured by the IV, could be used as an indicator of the market risk aversion, among other measures. The decision to choose a specific type of derivative instrument, however, should not solely be based on the market sentiment. Instead, one should take into consideration the nature of the risk exposure (whether linear or non-linear), accounting choices and cash balances in addition to the market sentiment as measured by the IVF.

4.5. Summary

The first element of this chapter examined the value-relevance of hedging for a global sample of 54 publicly traded airline companies which yields 411 firm year observations for the 13 year period between 2000 and 2012. The benefits of examining the airline industry can be outlined under four headings. First, the industry is significantly exposed to jet-fuel price risk. The proportion of jet fuel prices has exceeded one third of total operating expenses. Consequently, the industry cash flows and investments are extremely sensitive to adverse movements in oil prices. Second, the percentage levels of jet fuel hedges are readily available for the majority of airline companies. Third, given the intense, competitive environment, the industry can only transfer a limited portion of jet fuel price risks to customers, hence the availability of operational hedges are somewhat limited (excluding regional carriers). And four, the industry operates at low profit margins and utilizes significant financial leverage, potentially exposing companies to the risk of financial distress. As a result, this study examines the implications of jet fuel hedging for an industry in which, theoretically, the benefits from hedging are expected to be highest.

The basic tenet of corporate risk management theory is the reduction in variability of operating cash flows. Necessarily, the first question this study asks is whether hedging is useful in reducing variability in internal cash flows. The results of the univariate analysis suggest that the variability in operating cash flows and capital expenditures are significantly lower for hedgers than non-hedgers. The multivariate analyses in section 4.2.2 also indicate that both internal cash flows and capital expenditures are important contributors to firm value. Additionally, fuel costs as a percentage of total operating expenses are 6% lower for the hedging year observations compared to non-hedging year observations. These results indicate the benefits of jet fuel hedging in terms of preserving internal cash funds and alleviating potential underinvestment problems for both low cost carriers and major carriers.

The next question this study asks is whether there is a value premium associated with hedging under conditions when there are information asymmetries and greater risk of financial distress inherent in the sample of global airline companies. The sample is separated in to two sub-samples of 1) low cost carriers and 2) major carriers. This serves two purposes: First, it will permit a control for any economically important differences between these two business models, one in its high growth state (low cost carriers) and the other in its mature state (major carriers). And secondly, it will expose potential endogeneity related problems: firms with greater firm value hedge more. This potential problem is eliminated by the fact that both sub-samples have very similar hedge ratios, 32% for low cost carriers and 34% for major carriers. Using two Q measures for each regression, one of which adjusted for off-balance sheet leases, the results show that hedging has contributed to firm value for the low-cost carriers with a value premium between 5% - 8% , on average. However, there is no association between hedging and firm value for the major carrier sub-sample examined.

In their growth stage, the market values of low cost carrier firms are expected to be largely comprised of the present value of future growth opportunities. Lacking the implicit/explicit financial support of governments, and subject to significant competition for investment opportunities, low cost carriers use significantly lower debt financing relative to major carriers. This makes these high-growth firms more sensitive to the level of internally generated cash flows. Accordingly, it is only fair to expect low cost carriers to be more prone to significant underinvestment problems if they are unable to take advantage of investment opportunities due to funding constraints. In their mature stage, major carriers are less likely to experience underinvestment problems at a comparable scale to low cost carriers as the market values of these major carriers largely reflect the assets already in place rather than growth opportunities.

The diversity of companies in the sample enhances the ability to investigate various factors that could affect the implications of jet fuel hedging for different airline companies in different regions. For example, the U.S. airline industry has been completely deregulated since 1978. This was followed by European deregulation. Similarly, there can be regional differences that affect hedging decisions and the implications of corporate hedging. For example, government ownership is still prevalent outside of the U.S. as the industry is seen as a strategic one.

All these factors expose the results of this study to potential endogeneity issues. Having access to hedging information on a global scale, the study has the advantage to control for these cross-regional differences. Section 4.2.1 conducts univariate analysis that compares airline companies under government ownership with airline companies that are privately owned. Similarly, section 4.2.2 also controls for government ownership in the multivariate regressions by using categorical variables. Section 4.2.2 also controls for endogeneity related issues by using first differenced regressions, fixed effects regressions and instrumental variable regressions. An empirical observation of the positive association between hedging and firm value for the low cost carriers sub-sample is robust to these model specifications and estimations.

The second element of this chapter conducts a scenario-based case study of hedging using derivative instruments that are available to commodity end-users and compares the results to 1) a benchmark non-hedging scenario and 2) the actual operating and financial results of Turkish Airlines, which only started to hedge after 2008.

First, jet fuel prices are simulated ±50% around their mean levels for each year from 2005 to 2011. Each simulation is for 10000 observations. Next, spot rate curves and forward curves are estimated for the same time period. From these forward curves five classes of derivative instruments are priced. These include swaps, Asian options, collars, participating collars and four-way collars. These derivative instruments are then used to estimate effective fuel costs from which fuel cost savings are calculated. These fuel cost savings are derived from two test scenarios: 1) a benchmark non-hedging scenario and 2) the actual operating and financial results of Turkish Airlines. In addition, the effectiveness of each derivative instrument is critically examined and evaluated on the basis of the cash flow variability that each derivative instrument exposes the hedging program.

Overall, this study brings answers to the three questions outlined in section 1.3. The first question was whether an airline company receives any economically significant benefits from hedging strategies? The answer to this question is absolutely, yes. Results indicate that in both a non-hedging case study and the actual case study for Turkish Airlines, hedging can significantly improve financial performance through fuel cost savings. This is regardless of the fact that some derivative instruments perform better than others under certain market conditions.

The second question was whether selective hedging in terms of instrument choice is superior to instrument choice based on the characteristics of the risk exposure – a view widely accepted by the literature. Airline firms are mainly subject to oil price risks and to a significantly lesser extent to quantity risk as they know where to fly, which airplanes to use, and how many flights to make months in advance. As a result, they have the ability to estimate upcoming fuel consumption very precisely. Although commodity risk management can get complicated (particularly for end-users) given the highly volatile and dynamically changing market sentiment, minimizing quantity risk is a significant advantage.

The third and the final question asked whether a hedging portfolio can be “fine-tuned” using non-linear pay-off option instruments and combination strategies such as collars. There are two definitions for “fine-tuning” a hedging portfolio. Brown and Toft (2002) define “fine-tuning" as increases in the cash flow stream of a hedging portfolio, whereas Gerner and Ronn (2012) define it as reductions in hedging costs and overall gross exposure. This study combines these two definitions and examines a risk-benefit analysis of hedging positions. Risk is defined as the additional volatility inherent in the hedging instruments themselves. Benefit is defined as the fuel cost savings obtained from these derivative instruments. The results indicate that the inclusion of non-linear instruments into a linear hedging portfolio significantly reduces the volatility of the hedging portfolio. On the other hand, whether a non-linear derivative instrument can help save more on fuel costs is entirely dependent on the direction and the volatility of prices.

It is important to acknowledge certain assumptions that have been made in this study. First of all, the derivative instruments are priced for one year. The hedging program is also assumed to be one year in order to match with estimated derivative prices. So, the results in this study are free from any problems related to a maturity mismatch. In majority of the cases, however, companies hedge periodically and not necessarily for the entire year. On the other hand, some airline companies hedge some of their fuel consumption almost two years in advance. It is a known fact that derivative instruments do not provide the same level of liquidity for each maturity. As a result, the analysis in this study is also free from liquidity related cash flow concerns – a common problem airlines face in practice.

Moreover, in practice, airline companies determine a range or a band of oil prices in which the firm will be exposed to the highest acceptable level of cash flow risks and calculate the weighted average probability of exceeding this target cash flow risk. This approach is similar to the VaR approach but applied to cash flows and hence named as the cash flow at risk, CFaR. Having no access to cash flow projections of Turkish Airlines, this study assumes that the airline company is happy to fix its fuel price risk at the swap price. On the other hand, in reality airline companies are likely to obtain quotes from different traders for the price range where they feel they are exposed to the highest level of risks. With the availability of multiple counterparties to trade, airline companies might negotiate better prices and obtain more customized instruments to best serve their hedging strategies. Additionally, they can input their view on the market in to their hedging decisions - a concept referred to as "selective hedging". On the other hand, the forward curve estimated in this study will affect the price of each derivative instrument, hence the results of the analysis.

Similarly, it is assumed that there is no basis risk inherent in hedging positions. The term basis risk is used to describe the risk that the value of a hedged instrument/portfolio does not move in tandem with the value of the actual spot price exposure that is being risk managed. There are three types of basis risks: product basis, time basis and locational basis.

To summarize, the results in this section indicate that in terms of the risk-benefit profile, participating collars provided superior results compared to other instruments. These strategies provide the hedger with full upside price protection and enable him/her to take partial advantage of lower spot prices. The trade-off between the participating collars and instruments such as options which offer the full potential of lower prices is the lower cost of the total premium as a result of a short put option in a participating collar structure. The number of put option contracts sold is determined to be at a certain proportion (e.g. 50%) of the number of call option contracts purchased which would represent the participation ratio to falling market prices. The lower the participation ratio is, the more the hedger can take advantage of falling prices but at a cost of receiving a lower premium for the sale of put options.

Derivative instruments are widely used as an effective hedging mechanism by both financial and non-financial corporations. According to the Bank of International Settlements Derivative Statistics (2012), the total notional amount of OTC derivatives outstanding totalled $633 trillion at the end of December 2012. Interest rate derivative instruments have been the largest segment with the notional amounts standing at $490 trillion at the end of 2012. These are followed by foreign exchange derivatives with notional amounts at $67 trillion, equity-linked derivatives with notional amounts at $6.3 trillion and commodity derivatives with notional amounts outstanding at $3.2 trillion

An overlooked observation, however, is the fact that these OTC derivatives are only available to firms with a sufficient level of credit rating and assets (used as collateral). Bodnar et al.,

(1998) provide evidence that in 40% of the cases, counterparties demand a credit rating of AA or above for derivative transactions. Companies satisfying these conditions (usually larger and more established firms) can enjoy the benefits of the OTC market transactions through which they can obtain tailor-made instruments with a lessened degree of basis risk. On the other hand, these companies can alter their total risks and "fine-tune" their hedges using exotic options (Ronn and Gerner, 2012).

Most of the research examining the optimum choice of derivative instrument focuses on these firms. The general outcome of these studies is that the most important determinant of a derivative instrument is the company-specific nature of risk factor(s). That is, the correlation between firm level cash flows and price risk (Stulz, 2002; Brown and Toft, 2002; Gay, Nam and Turac, 2001).

Some research also suggests the use of market information as an important factor affecting hedging decisions: Stulz, (1996), Adam (2003), Brown et al., (2003) and Faulkender (2005). These studies, however, also draw their findings on similar type of firms that have access to OTC market.

For smaller companies with lower levels of tangible assets as collateral and an insufficient credit rating, these OTC instruments might not be available. For these companies it is critical to balance their firm-wide risks with an affordable risk management strategy as the choice of derivative instrument will require its own funding source (Parsons and Mello, 2000). Moreover, these companies will encounter additional volatility from the marked-to-market features of the exchange traded instruments. As a result, their hedging portfolios will be subject to a greater level of liquidity risk compared to large firms and/or firms with a sufficient credit rating which can enjoy OTC derivatives.

Consequently, determining which derivative instrument to use becomes much harder to associate only with the nature of the risk exposure. Derivative instruments in traded exchanges are unlikely to fully offset the risks arising as a result of the nature of the risk exposure. This is largely due to the fact that these instruments are subject to significant levels of basis risk (product basis, time basis and locational basis) which can generate serious liquidity problems on their own. Moreover, these exchange traded derivatives are shorter in maturity. The choice of instrument is particularly important in the short term since uncertainty in the long term can be dealt with by adjusting sales and marketing strategies, pricing and production capacity (Stulz, 2003).

The third element of this thesis tests a simple strategy that uses the information content of market sentiment measured by option implied volatilities as a methodology to assist in the determination of an instrument choice particularly for firms that are dependent on short-term exchange traded derivative instruments.

Studies examining the informativeness and/or the predictive power of the implied volatility function (IVF) provide mixed results. The ability to forecast future prices and trends differs significantly depending on the time period and the asset class examined. On the other hand, the relationship between the informativeness of the IVF and the instrument choice for hedging has not been examined before. This study is the first to examine whether the market sentiment measured by the IVF is useful in terms of choosing the right hedging instrument.

With this thinking in mind, the test strategy uses an IVF which suggests using linear pay-off futures when the difference between the implied volatilities of the far out-of-money options of consecutive contracts on crude oil futures traded in NYMEX are positive. In this case, market sentiment is bullish on oil prices and futures would be sufficient and a cost efficient way to hedge the risk exposure. When the difference between the implied volatilities of the far out-of-money options of consecutive contracts is negative, the test strategy suggests using non-linear pay-off option contracts. These instruments are more expensive but bring the flexibility to take advantage of lower prices should crude oil prices fall (as indicated by traders' positions). The benchmark strategy against which the IVF strategy is tested is a simple futures roll-over strategy.

Using NYMEX futures and options on futures, the results indicate that the strategy based on the predictive power of the IVF is not superior to a simple hedging strategy using futures.

Although one can argue that the informativeness of the IVF may differ by the time series properties of various asset classes, these results do indicate that the instrument choice should not be solely based on the market sentiment at least as measured by predictive power of the IVF.

5. CONCLUSIONS

5.1. Hedging and Firm Value

The first element of this study provides evidence supporting value maximization via hedging when firms have significant investment opportunities and potential financial distress costs and it confirms the underinvestment incentive for corporate risk management. What this study does differently than previous literature is that the research question is designed around the industry specific factors that would interact with the implications of corporate risk management. For example, this study doesn't compare operational measures of risk management to financial measures of risk management. This area of research is largely ignored by the literature or even sometimes confused with financial hedging. For example, Carter et al. (2006) mistakenly sampled major carriers which have limited ability to operationally hedge their jet fuel exposures with regional carriers which can utilize operational measures to almost completely eliminate their jet fuel risk exposure, hence do not need to use financial derivatives.

Needless to say, so many other papers on corporate risk management (not necessarily using airline industry sample) have also failed to incorporate operational hedging in their analysis. It is, therefore, important to either correctly incorporate the operational hedges in the analysis or correctly distinguish firms with the ability to utilize operational hedging from firms which are reliant on financial hedges. A research incorporating either of these approaches would significantly eliminate the risk of omitted variable bias whereas a research failing to control for any of them would magnify the risk of omitted variable bias.

A very recent study by Treanor, Simkins, Rogers, Carter (2014), proposes that both financial and operational hedging are important tools in reducing airline exposure to jet fuel price risk. However, operational hedging strategies appear to be more economically important. They argue that hedging with derivatives is more likely to "fine-tune" risk exposure, whereas operational choices have a higher order effect on risk exposure. They define operational hedging as 1) the extent to which airlines operate different aircraft types and 2) the degree to which airline operates fuel efficient fleets.

However, this form of definition of operational hedging brings two important questions to surface. First, LCCs are dominantly operating in short-haul segment and utilize a single type of aircraft which brings down the cost of maintenance (engineering costs are lower since that training needs of engineers are limited to a single type of aircraft), airport landing fees and increase the utility of the airplane through shortened time period between landing and take-off. This is a form of operational hedge even through the fleet is not composed of so many different type of airplanes. Therefore, the assumption of diversity in the fleet composition might not be the representative of an operational hedge for all airline companies as assumed by Treanor et al. (2014).

Second, only firms with the financial ability can afford to replace their less fuel efficient aircraft with those of high fuel efficient aircraft. Airline companies estimate a lifetime period of 15 to 20 years per aircraft and usually lease these aircrafts under either operational or finance lease conditions. Airline companies that cannot afford to replace all of their existing aircraft with fuel efficient ones are not able to benefit from this operational hedging. Hence, operational hedging is itself endogenous to hedging and firm performance which needs to be accounted for.

Therefore, it is still not clear what defines an operational hedge and separates it from financial hedge. In addition, the ways to identify the endogenous nature of the ability to utilize operational hedging and the correct application of carefully selected control variables in econometric models still need significant future research. The first element of this thesis doesn't aim to relate to any of the above discussion but it carefully identifies airline companies with the ability to utilize operational hedging from the rest of the airline companies. Consequently it minimizes the endogeneity and omitted variable related bias in the results.

Although the results of this study empirically document the benefits of hedging for a commodity end-user risk profile, they may also be influenced by the differences in risk management strategies and the financial instruments used which could be a subject for future research. For example the second element of this thesis shows that non-linear derivative instruments can significantly reduce cash flow variability of derivative positions hence, the overall positional risk exposure of the hedging program. It is clear that the literature needs to get more detailed information with regards to derivative instruments used and their maturity structure. Although it would only enhance the investor's understanding of the true risk exposure of a firm (airline companies in this thesis) this information is hard to obtain particularly for non-U.S. firms, which needs to be addressed by financial authorities and regulators.

Having considered these limitations/boundaries, the empirical observations of this study suggest that investors acknowledge the potential benefits of hedging for high-growth low cost carriers and reward the awareness and/or penalize the ignorance of risks related to oil prices for these companies. These findings confirm the underinvestment theory of corporate finance.

5.2. Hedging Effectiveness and Derivative Instrument Choice

This study investigates the effectiveness of different hedging instruments and compares hedging and non-hedging case studies using a real/active airline company data. The first element of this thesis investigates the value-relevance of hedging using continuous hedging data extracted from airline companies' annual reports and 10-K, 10-Q statements. This study documents that the success of a hedging program is not necessarily linearly associated with a percentage level of the risk factor being hedged but is also dependent on the characteristics of the derivative instruments used. From this point of view, the second element of this thesis complements the first element.

Corporate risk management literature provides theoretical evidence that non-linear pay-off options can improve the efficiency of a hedging program. Not many papers tested this claim empirically other than Gerner and Ronn (2012). They provide evidence, based on an actual airline company hedging its fuel consumption using linear pay-off futures, that the inclusion of non-linear pay-off options improves the cash flow generating ability of the combined portfolio. Authors call this “fine-tuning” of the existing hedging program. This study, different to Gerner and Ronn (2012), compares a hedging scenario using a variety of derivative financial instruments to a non-hedging scenario. The fuel consumption, hedging and operational data used in the analysis is from Turkish Airlines. Results of this study complement the “fine-tuning” argument in Gerner and Ronn (2012) that the inclusion of non-linear pay-off strategies significantly reduces the variability in cash flows of the hedging program. In addition, hedging, regardless of the type of derivative instrument used, could have saved Turkish Airlines millions of dollars in fuel bill.

The findings of this study complement the first element of this thesis. The summary outcome of both sections is that hedging seems to have benefited airline companies in the last decade. For some airline companies, these benefits resulted in value premium and increased their shareholder value more than others. But operational efficiency gains in terms of reduction in cash flow variability, reduction in the proportion of fuel costs in operating expenses are mutually observable for all airline companies sampled.

5.3. Hedging with Futures and Options: The Role of Implied Volatility

The hedging decisions of small firms with no access to over the counter derivatives markets remain largely unexplored. This study aims to provide a simple methodology that could be applied in hedging programs of small firms with insufficient credit rating and are dependent on the exchange traded markets which subject them to significant level of basis and cash flow risks. What’s more, these firms roll-over their hedging positions more frequently as the liquidity of the contract is an important matter once the company decides to reverse its position and can only be found in near term contracts traded on NYMEX.

This study tests the information content of the implied volatility function as the determinant of the oil price movements. Since there is a group of oil end-users who are reliant on the exchange traded instruments and they roll-over their hedging contracts frequently, why don't these companies listen to what markets say. The idea of this study is to measure the market sentiment of the oil market using the implied volatility of the crude oil options on futures traded in NYMEX. Simply put, the more anxious traders are about the future prices of oil the more they will position themselves at the far end of out-of-money options. Using the increase/decrease in the implied volatilities of these options firms can forecast the direction of oil prices and determine whether they should go for futures contracts with no upfront premium or rather choose options with upfront premium. If the market is bullish on oil the preference will be on futures whereas if the market is bearish on oil the preference will be on options.

The literature on the information content of the implied volatility function yields mixed evidence and is dependent on the time series properties of the asset class examined. This study shows that IVF, as a measure of the market sentiment of the direction of oil prices, do not provide a superior hedging strategy compared to a simple futures roll-over strategy. These results might be due to the time series properties of the IVFs.

Corporate risk management literature, however, still have not provided supporting empirical evidence on the theoretical models on the optimal choice of derivative instruments, which should definitely be a subject of further study. Empirical evidence show that "selective hedging" has been increasingly prominent in corporate risks management particularly among commodity producers and mining companies. This type of hedging incorporates managerial expectations into hedging decisions but the scope of these analyses is limited to the timing and the magnitude (percent of hedge) of hedges. As the first two elements of this chapter document, there is the third dimension to "selective hedging" other than the timing and the magnitude which is the choice of derivative instruments. Future research should be able to incorporate this third dimension into "hedging behaviour" of these companies.

Moreover, further research might focus on different ways to measure the market sentiment other than the implied volatility functions such as the hedging pressure and their role in assisting choosing the right derivative instrument.

5.4. Limitations of the Research

The most important limitation of the first element of this thesis is that the sample is constrained by the lack of consistency in the disclosure of hedging data for non-U.S. airline companies. European airline companies only started to disclose the necessary information on fuel risk management after the implementation of International Accounting Standard 32 (Disclosure of Financial Instruments, IAS32) for financial years beginning in January 2005, prior to which disclosure had been voluntary. The availability of quantitative hedging data for international airline companies is still dependent on voluntary disclosure. This lack of data for non-U.S. firms limits the observations for non-U.S. firms to the year 2005 and onwards which results in greater firm – year observations for the sample period after 2005.

In addition, data screening process which require the elimination of firms with only qualitative information on hedging results in exclusion of some of the data from the analysis. As argued in section 3.1 both of the above mentioned limitations result in an unbalanced panel, but provide the most diversified sample of the airline industry. In fact, the paper controls for this limitation in the analysis presented in Appendix 3 which confirms the results for the low cost carriers sample obtained in section 4.2.2.

And finally, the first element of this thesis cannot analyse the interaction between operational hedging using fuel surcharges and financial hedging due to data constraints. Fuel surcharge data is unique and very hard to obtain but may enclose a number of economically and statistically important properties that might help us better understand the coordination between operational and financial hedging. For U.S. firms the data is somewhat more accessible than non-U.S. firms for which the data almost doesn't exist. Still, the importance of such specialized data could only be captured if the data is available in quantitative format rather than qualitative format.

It is no secret that airline companies periodically utilize fuel surcharges and try to pass on some portion of their fuel bill onto their customers. Since all airline companies, including LCCs, resort to fuel surcharges, only quantitative information on fuel surcharges would help estimate the true magnitude of cash flow burden of fuel bill is transferred on to customers. Unfortunately this data is totally company-specific. As mentioned in section 5.1, however, the first element of this thesis successfully separate airline companies (regional carriers) who has significant advantage in using these operational measures of jet fuel risk management from those airline companies (LCCs and MCs) who relatively cannot.

The most prominent limitation of the second element of this thesis is that the estimated forward curves are likely to be different from the actual forward curves available for the sample period examined. Depending on the complexity of operations and demand from the willing counterparties, traders estimate and quote prices of oil contracts for as small intervals as hourly, daily and weekly observations. Unfortunately, access to such detailed information is not possible. Potential inconsistency in estimated and actual forward curves is acknowledged as one of the important limitations of the second element as these estimated forward curves directly affect the swap contract prices which are used later in the analysis.

Moreover, the second element makes two more assumptions that are acknowledged as the limitations of this section. First it is assumed that the start date of Libor-based spot rates exactly corresponds to the start dates of futures contracts. It is also assumed that the maturities of Libor-based spot rates exactly match the maturities of forward curves. Both of these assumptions eliminate the entire maturity risk. Second, it is assumed that Turkish Airlines is able to make the required upfront cash payments for the option type instruments. In practice airline companies are reluctant to pay such great amounts in advance even though they need the protection.

The third element of this thesis has two limitations. First it is assumed that both futures and option contracts to be closed and/or rolled over two days before the end of the contract maturity. This method is based on the two-day measure is used as standard by Hull (2008). However, in practice, traders might close their positions earlier based on the observed and/or expected liquidity of the contract month. Second, the implied volatility data used in this section is from Bloomberg. Bloomberg only started publishing this data from 2006 and onwards. Hence the analysis is limited to the observations from 2006 and onwards which might affect the results given that implied volatility functions are sensitive to time-series properties of the assets.

5.5. Summary and Avenues for Future Research

This thesis provides evidence that jet fuel risk management using derivative instruments improves both operational and financial efficiency of airline companies. For example, hedging helps reduce fuel costs, variability in cash flows and variability in capital expenditures for all sampled firms. For high growth airline companies with significant investment opportunities, the operational and financial gains obtained from hedging can help preserve the essential internal cash flows needed to carry out investments. When considered that these airline companies are more reliant on internal financing than outside financing in their investments, having the necessary capital when it's most needed will help alleviate the potential underinvestment problems for these airlines and increase shareholder value. It is also evidenced that the success of a hedging program is, to a very large extent, dependent on the type(s) of derivative instrument(s) used. Particularly the inclusion of non-linear pay-off options "fine-tunes" already existing linear pay-off derivative instruments in terms of reduction in cash flow volatility exposure.

The results of this thesis identifies several areas that require further research to help enhance ones understanding of the implications of corporate risk management. Corporate risk management combines both operational risk management and financial risk management. Despite the substantial theoretical and empirical work in financial risk management there is still not enough research done on operational risk management. In fact, as mentioned in section 5.1 empirical studies in corporate risk management either fail to identify group of companies that are more able to utilize operational measures of hedging or they fail to control for these measures in their models, hence suffer from a significant omitted variable bias. This thesis reveals that it is essential to either correctly choose the sample that will exclude firms with greater ability to operationally manage their risks from those that cannot or control for the measures of operational risk management in the analysis itself. On the downside, corporate risk management literature failed to identify what really is operational risk management and how to measure it. Operational risk management measures such as corporate diversification, multinational operations and diversity in product range set forth in the literature all suffer from endogeneity. These operational risk measures are used mostly by large firms with substantial history and financial capital which largely limits the use of them outside of this specific sample group. A significant contribution would be to identify measures of operational risk management that are as free from endogeneity related biases as possible. It therefore makes more sense to examine specific industries that would yield more detailed and homogenous information about potential measures of operational hedging.

Moreover, the literature needs more work on detailed examination of derivative instruments used in corporate risk management. The research on this area will continue to be limited to commodity producers and end-users since these companies provide the greatest detail that could possibly be obtained from any financial report. It would be a significant contribution to the literature if research can identify the interplay between operational risk management and derivative instrument choice, if any.

And finally the literature, particularly from an empirical point of view, needs more work on hedging practices of small firms with limited or no access to over the counter derivative instruments. Selective hedging which incorporates management discretion on hedging decision is a widely accepted practice in the literature. However, selective hedging is limited to the timing and the magnitude of hedging and doesn't incorporate the choice of derivative instrument. In parallel to the argument of selective hedging, this thesis attempted to provide a simple methodology that use the market sentiment measured by the implied volatility function to help determine whether firms should use linear pay-off or non-linear pay-off derivatives. The implications of using linear and non-linear pay-off derivatives are of greater importance for firms with limited liquid reserves and with only access to exchange traded derivative markets. This is simply because mark-to-market features of the exchange traded instruments that these companies use might require significant cash infusion as part of maintenance margin system.

Moreover, these exchange traded contracts are shorter term in nature and must be rolled over more frequently than over the counter derivatives. A carefully chosen cash flow pay-off structure can help minimize cash outlays and provide more stable protection from the fluctuations in oil prices. Further research on this topic might use different measures of market sentiment that could assist the management in the choice of optimum derivative instrument pay-off structure. In addition, more detailed empirical analysis of derivative instruments used in corporate risk management will reveal more detailed insights into the implications and determinants of selective hedging.

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Table 1
Descriptive Statistics

Panel A displays in detail the total firm–year data for various levels of hedging percentages (abbreviated as H) for the total sample and the two sub-samples studied. Panel A also presents descriptive statistics for three main regions in the analysis and for additional regional samples. The second row partitions the percentage of fuel consumption hedged into frequency intervals which ranges from zero hedging in column 2 to 90% hedging in column 10. Columns 2 to 10 also summarize the ratio of total number of firm-years in each hedging level. Rows 3 to 5 display the number of firm-year observations that fall into each hedging bracket for the total sample, low cost carriers sample and major carriers sample. Rows 6 to 8 display the proportion of the firm year observations in each hedging bracket to the total number of observations in each sample examined. Hedging statistics for a regional samples examining the U.S., European. and international companies are also presented. Panel B and Panel C and provide summarized information on hedging, firm value and other control variables for the LCC and MC sub-samples as well as regional segments. Dependent variable Tobin's Q (TBQ), the test variable hedging (Hedging) and other control variables presented in Panel B are the actual (unadjusted) observations for the sample. Panel C presents the same data adjusted for the off-balance sheet lease obligations where the present values of operating leases are added back on "Total Assets" and "Total Debt", which in turn adjust "Return on Assets", "Financial Leverage" and "Tobin's Q". In Panel B and Panel C, columns 2, 3, and 4 show the mean levels of fuel consumption hedged, the ratio of fuel cost to operating expenses, and return on assets (Net Income/Total Assets) in percentages. Columns 5 and 6 show the amount of financial leverage used (Total Debt/Total Equity) and the natural logarithm of the assets. Columns 8, 9, and 10 show cash flow from operations and capital expenditures both scaled by revenues (CFO/Rev and Capex/Rev) and values of Tobin's Q. The only variables that are different in Panel C compare to Panel B are profitability, leveage, firm size control variables, and the firm value which are adjusted for off-balance sheet leases. The mean levels of hedging are 34% for the "total sample", 32% for the "LCC sample", 34% for the "major carriers sample", 27% for the "U.S. sample", 38% for the Non- U.S Sample.

Panel A: Distribution of Firm Year Observations per Hedging Percentage Level

SAMPLE GROUPS	H≤0%	H≤10%	H≤20%	H≤Mean	H≤50%	H≤60%	H≤70%	H≤80%	H≤90%
Study Sample	88	101	142	201	297	333	363	392	405
Total Sample									
LCC Sample	33	42	57	82	97	106	114	127	134
MC Sample	55	59	85	124	200	227	249	265	271
Pct. of Total S.	22%	25%	35%	49%	73%	81%	89%	96%	99%
Pct. of LCCs	24%	31%	42%	60%	71%	78%	84%	93%	99%
Pct. of MCs	20%	21%	30%	44%	71%	81%	89%	94%	97%
Reg. Sample									
US Airlines	20	29	52	64	115	118	121	125	127
European Air.	9	12	18	48	51	72	96	111	120
Int. Airlines	59	59	71	84	128	140	144	153	155
Pct. of US S.	16%	23%	41%	50%	90%	92%	95%	98%	99%
Pct. of EU S.	7%	10%	15%	39%	42%	59%	79%	91%	98%
Pct. of INT S.	37%	37%	45%	53%	81%	88%	91%	96%	97%

Table 1 Continued

PANEL B: Summary Statistics of Unadjusted Control Variables								
	Hedging	Fuel/Opex	RoA	Lvrg.	Log assets	CFO/Rev	Capex/Rev	TBQ
Study Samples								
Total Sample	34%	28%	1%	6.7	9.1	11%	14%	1.2
LCC Sample	32%	30%	3%	2	8	16%	23%	1.48
MC Sample	34%	28%	0%	8.5	9.7	8.60%	11%	1.13
Regional Samples								
U.S. Airlines	27%	28%	1.00%	14.5	8.3	9%	12%	1.3
Non-U.S. Airlines	38%	29%	1.10%	4.3	8.3	11%	15%	1.21

Panel C: Summary Statistics of Control Variables Adjusted for Off-Balance Sheet Leases								
	Hedging	Fuel/Opex	RoA	Lvrg.	Log assets	CFO/Rev	Capex/Rev	TBQ
Study Samples								
Total Sample	34%	28%	1%	9.6	9.4	11%	14%	1.18
LCC Sample	32%	30%	3%	4.3	8.1	16%	23%	1.4
MC Sample	34%	28%	1%	11.8	9.9	9%	11%	1.08
Regional Samples								
US Airlines	27%	28%	1%	22	21.9	9%	12%	1.22
Non-U.S. Airlines	38%	29%	1.2%	6.1	8.5	11%	15%	1.17

Table 2
Test of Cash Flow Variability and Fuel Cost Efficiency

In Panel A, the differences among hedging-firm year observations and non-hedging firm year observations are analyzed statistically. The mean and median values of both unadjusted and adjusted values of dependent variable, firm value (UAQ and Adj.Q) and all control variables; capital expenditures (Capex/Rev), operating cash flows (CFO/Rev), return on assets (RoA and RoA Adj.), fuel costs as a percentage of operating expenses (Fuel/Opex) and leverage (Leverage and Leverage Adj.) for hedging and non-hedging firm-year observations are compared. Panel A also estimates and compares the equality of the standard deviations of all the control variables, σ(Variable). Panel B, compares the same control variables as in Panel A for low-cost carriers and major carriers. In both Panel A and Panel B, it is assumed unequal variances for mean differences using Welch's degress of freedom (1947) and Wilcoxon's rank-sum test for the median differences (1945). Panel A uses Bartlett's generalization of F-test to compare the variances in each control variables. In the final columns of Panels A and C, the p values of statistical significance are reported. The numbers in brackets are critical t-values. Asterisks above the parentheses represent significance levels: * is used for 10%, ** is used for 5% and *** is used for 1% significance levels. Panel C investigates the relation between Fuel/Opex and the percentage of the next year's fuel consumption hedged (hedging (t-1)) at time (t-1). It uses the equally weighted average of spot market jet fuel prices and firm size as control variables.

Panel A: Univariate Test of Control Variables for the Hedging and Non-Hedging Firm-Year Observations

Variable	Hedgers Sample	Non-Hedgers Sample	Difference	*t*-statistics (mean) *z*-statistics (median) *F*-test (σ)	p-Value
UAQ (mean)	1.23	1.3	-0.08	-1.30	0.20
UAQ (med.)	1.09	1.13	-0.04	-1.30	0.20
σ(UAQ)	49%	48%	0.01	0.00	1.00
Adj.Q. (mean)	1.18	1.23	-0.05	-1.00	0.30
Adj.Q. (med.)	1.08	1.1	-0.02	-0.40	0.70
σ(Adj. Q)	42%	36%	0.05	0.00	1.00
Capex/Rev (mean)	13.4%	16.5%	-4%	-1.40	0.00
Capex/Rev (med.)	10%	10%	0%	-0.30	0.70
σ(Capex/Rev)	15%	21%	-6%	1.73*	0.70
CFO/Rev (mean)	10.7%	9.30%	1.4%	1.10	0.30
CFO/Rev (med.)	10.4%	11%	-0.6%	0.10	0.90
σ(CFO/Rev)	10%	14%	-4%	2.30**	0.02
RoA (mean)	1.5%	0.00%	1.5%	1.20	0.20
RoA (med.)	2.3%	3.00%	-1.3%	-0.20	0.90
σ(RoA)	10%	10%	0%	0.00	1.00
RoA Adj. (mean)	1.2%	0.7%	0.5%	0.60	0.60
RoA. Adj. (med.)	1.8%	1%	0.8%	0.00	1.00
σ(RoA. Adj)	8%	7%	1%	0.00	1.00
Fuel/Opex (mean)	28%	34%	-6%	-5.80***	0.00
Fuel/Opex (med.)	29%	31%	-2%	-5.70***	0.00
σ(Fuel/Opex)	9%	9%	0%	0.00	1.00
Lvrg (mean)	5	11.6	-6	-3.60***	0.00
Lvrg (med.)	2.5	4.2	-1.7	7.10***	0.00
σ(Lvrg)	12%	24%	-12%	0.00	1.00
Lvrg Adj. (mean)	6.8	18.2	-11	-4.40***	0.00
LvrgAdj. (med.)	3	5.2	-2.2	-4.00***	0.00
σ(Lvrg Adj.)	15%	37%	-21%	0.00	1.00

Table 2 continued

Panel B: Univariate Test of Control Variables for the Low Cost and Major Carriers					
Variables	LCC Sample	MC Sample	Difference	*t*-statistic (mean) *z*-statistic (median)	p-Value
UAQ (mean)	1.48	1.13	0.35	7.89***	0.00
UAQ (median)	1.31	1.06	0.25	26***	0.00
Adj.Q (mean)	1.38	1.1	0.28	7.37***	0.00
Adj.Q (median)	1.2	1.04	0.16	28.4***	0.00
Hedging (mean)	33%	35%	-2%	-0.67	0.50
Hedging (median)	30%	34%	-4%	-1.79*	0.18
Capex /Rev (mean)	23%	11%	12%	6.9***	0.00
Capex/Rev (median)	15%	8%	7%	16***	0.00
CFO/Rev (mean)	16%	9%	7%	5.95***	0.00
CFO/Rev (median)	14%	9%	5%	18.0***	0.00
RoA (mean)	3%	1%	2%	2.31**	0.02
RoA (median)	4%	2%	2%	14.39***	0.00
RoA Adj. (mean)	3%	1%	2%	2.44***	0.02
RoA. Adj. (median)	3%	1%	2%	9.8***	0.00
Fuel/Opex (mean)	30%	28%	2%	2.70***	0.00
Fuel/Opex (median)	29%	28%	1%	0.30	0.59

Table 3
Univariate Test of Government Ownership

Panel A conducts a univariate test on the differences between the mean and median values of both unadjusted firm value (UAQ) and adjusted firm value (Adj.Q), hedging, capital expenditures (Capex/Rev), operating cash flows (CFO/Rev), return on assets (RoA), and fuel costs as a percentage of operating expenses (Fuel/Opex) for both airline companies with government ownership and privately owned airline companies. The first column lists the control variables tested. The second and third columns list the parameters for privately owned and airlines with government ownership respectively. The fourth column shows the differences between the control variables and column five displays the statistical significance of these differences. Both Panel A and Panel B assume unequal variances for mean differences using Welch's degress of freedom (1947) and Wilcoxon's rank-sum test for the median differences (1945). the final columns report p-values of statistical significance.

Panel A: Univariate Test for Airlines with Government Ownership vs. Private Ownership

Variables	Priv. Own	Gov. Own	Difference	*t*-statistics (mean) *z*-statistics (median)	p-Value
UAQ (mean)	1.31	1.06	0.26	7.20***	0.00
UAQ (median)	1.14	0.98	0.16	6.81***	0.00
Adj.Q (mean)	1.11	1.06	0.04	5.86***	0.00
Adj.Q (median)	1.24	0.99	0.25	6.08***	0.00
Hedging (mean)	35%	30%	5%	2.21**	0.00
Hedging (median)	37%	29%	8%	2.00**	0.05
Capex /Rev (mean)	16%	12%	4%	3.56***	0.00
Capex/Rev (median)	10%	9%	1%	1.59	0.11
CFO/Rev (mean)	11%	10%	1%	2.70***	0.00
CFO/Rev (median)	11%	8%	3%	2.52***	0.01
RoA (mean)	1.4%	0.5%	1%	1.10	0.27
RoA (median)	2.7%	1.8%	1%	2.69***	0.00
RoA Adj. (mean)	1.4%	0.5%	1%	1.58	0.12
RoA. Adj. (median)	2%	1.4	0.6%	2.50***	0.01
Fuel/Opex (mean)	29%	30%	0%	1.06	0.29
Fuel/Opex (median)	29%	31%	0%	0.78	0.44

Table 3 continued

Panel B: Univariate Test for Major Carriers with Government Ownership vs. Private Ownership					
Variable	Non-Gov.MC	Gov. MC	Difference	*t*-statistics (mean) *z*-statistics (med.)	p-Value
UAQ (mean)	1.15	1.06	0.09	3.09***	0.00
UAQ (median)	1.09	0.98	0.12	4.63***	0.00
Adj.Q (mean)	1.11	1.06	0.04	2.05**	0.04
Adj.Q Measure (median)	1.06	0.99	0.07	3.83***	0.00
Hedging (mean)	39%	26%	13%	2.88***	0.00
Hedging (median)	38%	29%	9%	2.53***	0.01
Capex /Rev (mean)	10%	12%	-2%	-0.28	0.78
Capex/Rev (median)	8%	9%	-1%	-0.40	0.62
CFO/Rev (mean)	9%	10%	-1%	0.32	0.74
CFO/Rev (median)	9%	8%	1%	0.69	0.49
RoA (mean)	0%	0%	0%	-0.17	0.87
RoA (median)	2%	2%	0%	0.74	0.46
RoA Adj. (mean)	0%	0%	0%	0.06	0.95
RoA. Adj. (median)	1%	1%	0%	0.70	0.49
Fuel/Opex (mean)	27%	29%	-2%	-0.82	0.41
Fuel/Opex (median)	27%	29%	-2%	-0.82	0.39

Table 4
Multivariate Analysis of Firm Value and Hedging

Panel A (below) displays the regression analysis and the relationship between firm value and hedging for the 2 sub-sample groups examined: the low cost carriers sample and the major carriers sample. In Panel A, we analyse firm value and the hedging relationship using the following model:

$$Log\ of\ Tobins\ Q\ =\ \beta 1 \times\ Hedging\ \ + \Sigma(\beta i \times Conrol\ Variable\ i\ ) +\ \varepsilon.$$

There are a total of 411 firm-years of which 136 belong to the low cost carriers sample while 275 belong to the major carriers sample. Panel A examines the relation between unadjusted firm value and hedging. Panel B examines the relation between firm value adjusted for off-balance sheet leases and hedging. For all the samples examined, we use the usual ordinary least squares model with Huber-Sandwich robust standard errors (OLS R.) and the generalized least squares regression with robust standard errors adjusted for heteroskedasticity (GLS R.). The numbers in parentheses represent t-values for the OLS models and z-values for the GLS model. The numbers in brackets represent critical t and z values for OLS and GLS regressions respectively. Asterisks above the parantheses represents significance levels: * is used for 10%, ** is used for 5% and *** is used for 1% significance levels.

Panel A: Dependent Variable is Unadjusted Tobin's Q				
	LCC Sample		MC Sample	
	OLS R.	GLS R.	OLS R.	GLS R.
Observations	136	136	275	275
R^2	0.4		0.28	
Wald chi^2		118.26		83.49
Log(assets)	-0.079** (-2.51)	-0.12*** (-5.15)	0.03*** (4.82)	0.02*** (4.39)
Leverage	0.005 (1.03)	0.0011 (0.39)	0.0003 (1.41)	0.0001 (0.95)
RoA	1.11** (2.3)	1.34*** (3.8)	0.39 (1.44)	0.152*** (2.65)
Hedge	**0.25** (2.27)**	**0.36*** (3.81)**	**-0.013 (-0.25)**	**-0.043 (-1.20)**
CFO/Rev	0.41 (1.48)	0.65** (2.69)	0.29* (1.67)	0.49*** (2.66)
Capex/Rev	0.35*** (3.15)	0.29*** (2.81)	0.24 (1.42)	0.104 (0.86)
Dividends	-0.11 (-1.06)	0.00 (0.13)	0.013 (0.45)	-0.002 (1.32)
HIR	-0.017 (-0.30)	-0.01 (-0.24)	0.04* (1.86)	0.146 (0.73)
HFXP	-0.07 (-1.29)	-0.08 (-1.04)	-0.146*** (-4.77)	-0.115*** (-5.18)

Table 4 Continued

Panel B: Dependent Variable is Adjusted Tobin's Q				
	LCC Sample		MC Sample	
	OLS R.	GLS R.	OLS R.	GLS R.
Observations	136	136	275	275
R^2	0.37		0.28	
Wald chi^2		133.68		95.74
Log(assets)	-0.060** (-2.24)	-0.083*** (-4.20)	0.025*** (4.47)	0.018*** (4.11)
Leverage	-0.0018 (-0.72)	-0.0002 (-0.24)	0.0001** (2.05)	0.0000 (1.24)
RoA	2.05*** (3.26)	1.83*** (3.92)	0.33* (1.92)	0.19*** (2.43)
Hedge	**0.24** (2.10)**	**0.33*** (4.06)**	**-0.056 (-0.75)**	**-0.07 (-0.23)**
CFO/Rev	0.196 (0.73)	0.43** (2.09)	0.485** (2.22)	0.43*** (2.90)
Capex/Rev	0.284*** (3.13)	0.27*** (3.13)	0.188 (1.16)	0.078 (0.86)
Dividends	-0.107 (-1.15)	-0.019 (-0.34)	0.0045 (1.05)	0.027* (1.65)
HIR	0.018 (0.39)	-0.00 (-0.19)	0.032 (1.46)	0.012 (0.70)
HFXP	-0.062 (-1.26)	-0.04 (-1.14)	-0.114*** (-4.40)	-0.097*** (-5.00)

Table 5
Low Cost Carriers Robustness Analysis I

Panel A and B of Table VI conduct robustness checks on the value premia obtained for the low-cost carriers' hedging practices. Columns 2 and 3 present the OLS regression results on the first differenced data analysis for unadjusted and adjusted firm value and control variables. Columns 4 and 5 provide a quantile regression analysis on the unadjusted and adjusted firm value and control variables. Columns 2 and 3 of Panel B perform fixed effects models for both the unadjusted and adjusted firm value and control variables. Columns 4 and 5 of Panels B use Quantile regressions on both the unadjusted and adjusted firm value and control variables. Panel C conducts instrumental variable analyses on both LCC and MC sub-samples. The instruments used are 1) managerial stock options, 2) expected oil prices (Reuters Oil Poll), 3) the ratio of off-balance sheet leases to total assets and 4) the proportion of the number of rival firms hedged to the total number of rival firms. Asterisks above the parentheses represent significance levels: * is used for 10%, ** is used for 5% and *** is used for 1% significance levels.

Panel A Dependent Variable Log of Tobin's Q				
	First Diff.	First Diff. Adj.	Quantile	Quantile Adj.
Observations	120	120	136	136
R^2	0.35	0.31	0.2183	0.2
Log(assets)	-0.36*** (-4.1)	-0.52*** (-3.40)	-0.064*** (-2.18)	-0.041* (-1.76)
Leverage	0.003 (1.26)	-0.0017 (-1.43)	0.013*** (3.03)	-0.0001 (-0.1)
RoA	1.083*** (5.17)	1.24*** (3.70)	1.063** (2.27)	0.91 (1.44)
Hedge	**0.167** (2.00)**	**0.315*** (2.74)**	**0.208 (1.60)**	**0.198** (1.91)**
CFO/Rev	0.15 (0.87)	0.028 (0.13)	0.473 (1.49)	0.47** (1.78)
Capex/Rev	-0.065 (-0.62)	-0.16 (-0.96)	0.33** (2.18)	0.298*** (2.40)
Dividends	-0.022 (-0.35)	-0.0035 (-0.06)	-0.002 (-0.02)	-0.0037 (-0.05)

Table 5 Continued

Panel B: Dependent Variable Log of Tobin's Q				
	FE	FE Adj.	Cluster	Cluster Adj.
Observations	136	136	136	136
R^2	0.72	0.69	0.33	0.37
Log(assets)	-0.33***	-0.29***	-0.078	-0.065
	(-8.96)	(8.96)	(-1.27)	(-1.11)
Leverage	0.000	0.000	0.003	-0.018*
	(0.32)	(-1.41)	(1.30)	(-1.79)
RoA	1.09***	1.02***	1.10***	2.05***
	(4.47)	(4.47)	(3.29)	(4.50)
Hedge	**0.29*****	**0.26*****	**0.17**	**0.24***
	(3.40)	**(3.4)**	**(1.25)**	**(1.91)**
CFO/Rev	0.28	0.15	0.41	0.18
	(1.39)	(0.82)	(1.38)	(0.65)
Capex/Rev	0.07	0.17	0.35***	0.30***
	(0.73)	(0.2)	(2.89)	(2.54)
Dividends	-0.1	-0.006	-0.10**	-0.95
	(-1.58)	(-1.60)	(-0.80)	(-0.85)
HIR	0.019	0.033	-0.17	0.018
	(0.26)	(0.54)	(-0.16)	(0.19)
HFXP	0.20	0.00	-0.07	-0.06
	(0.22)	(0.04)	(-0.76)	(-0.76)

Panel C: Instrumental Variable Regression				
	LCC	LCC Adj.	MC	MC Adj.
Observations	136	136	275	275
R2	0.34	28	0.19	0.17
Log(assets)	-0.11***	-0.07***	0.03***	
	(-3.05)	(-2.77)	(5.48)	0.025*** (4.73)
Leverage	0.006	-0.002	0.00	0.00
	(1.55)	(-1.22)	(0.76)	(0.76)
RoA	0.81*	1.68***	0.26**	0.34***
	(1.72)	(2.46)	(2.32)	(2.69)
Hedge	**0.414***	**0.46**	**-0.156**	**-0.035**
	(1.72)	**(1.62)**	**(-1.13)**	**(-0.40)**
CFO/Rev	0.1	-0.04	0.34***	0.50***
	(0.28)	(-0.14)	(3.12)	(3.56)
Capex/Rev	0.38***	0.32***	0.18*	0.21*
	(2.68)	(2.74)	(1.69)	(1.65)
Dividends	-0.05	-0.07	-0.02	-0.00
	(-0.56)	(-0.94)	(-0.06)	(-0.07)

Table 6
Low Cost Carriers Robustness Analysis II

Panels A and B perform categorical variable regressions. Panel A uses a low cost carrier dummy variable (lccdummy) and interaction variable (hedgeLCC). Columns 2 and 3 perform ordinary least squares (OLS R.) regressions with heteroskedastically adjusted standard errors on both the unadjusted and adjusted firm value and control variables. Columns 4 and 5 perform generalized least squares (GLS R.) regressions with heteroskedastically adjusted standard errors on both the unadjusted and adjusted firm value and control variables. Columns 2 and 3 in Panel B use regional dummy variables (USdummy and EUdummy to represent U.S. firms and European firms, respectively) and to apply international carriers as base. Additionally, the analyses use the interaction variables hedgeUS and hedgeEU which control for the level of fuel consumption hedged by each region. The "hedging" control variable in column 4 represents the level of fuel consumption hedged for privately held major carriers only. All of the regressions in both panels use heteroskedastically adjusted standard errors. Asterisks above the parentheses represent significance levels; * is used for 10%, ** is used for 5% and *** is used for 1% significance levels. The numbers in brackets are critical t-values.

Panel A: Dependent Variable Log of Tobin's Q				
	OLS R.	OLS R. Adj.	GLS R.	GLS R. Adj.
Observations	411	411	411	411
R^2	0.32	0.33		
Wald chi^2			210.56	198.47
Log(assets)	0.014* (1.82)	0.01*** (1.53)	0.006 (1.38)	0.05 (1.39)
Leverage	0.000 (1.17)	0.0002 (1.46)	0.000 (1.21)	0.0001* (1.68)
RoA	0.46*** (3.40)	0.51* (1.84)	0.43** (4.13)	0.40*** (3.44)
Hedge	-0.029 (-0.42)	-0.034 (-0.69)	-0.05 (-1.50)	0.20* (1.91)
CFO/Rev	0.48*** (3.29)	0.50*** (3.29)	0.41*** (4.05)	0.47* (1.78)
Capex/Rev	0.35*** (3.97)	0.31*** (4.01)	0.33*** (4.12)	0.30*** (2.40)
Dividends	-0.03 (-0.98)	-0.008 (-0.31)	-0.01 (-0.62)	-0.003 (-0.05)
LCCdummy	0.16*** (3.47)	0.08* (1.77)	0.13*** (3.26)	0.05 (1.63)
HedgeLCC	**0.16* (1.65)**	**0.22** (1.97)**	**0.21** (2.31)**	**0.26*** (3.40)**

Table 6 Continued

Panel B: Dependent Variable Log of Tobin's Q				
	OLS R.	OLS R. Adj.	GLS R.	GLS R. Adj.
Observations	411	411	411	411
R^2	0.34	0.35		
Wald chi^2			274.5	239.67
Log(assets)	0.000 (1.03)	0.003 (0.36)	-0.02 (-0.51)	-0.001 (-0.23)
Leverage	0.000 (1.07)	0.0002 (1.23)	0.000 (1.01)	0.0001 (1.49)
RoA	0.47* (1.84)	0.53** (1.97)	0.41*** (3.80)	0.38*** (3.28)
Hedge	0.06 (0.70)	0.04 (0.50)	0.03 (0.61)	0.02 (0.04)
CFO/Rev	0.46*** (2.65)	0.47*** (3.20)	0.37*** (3.64)	0.37*** (3.78)
Capex/Rev	0.32*** (3.19)	0.29*** (3.78)	0.24*** (3.40)	0.23*** (3.82)
Dividends	-0.05 (-1.34)	-0.02 (-0.81)	-0.025 (-1.29)	-0.02 (-1.09)
LCCdummy	0.13** (2.10)	0.06 (1.16)	0.12*** (2.83)	0.05 (1.28)
HedgeLCC	**0.21** **(1.56)**	**0.27**** **(2.25)**	**0.18**** **(2.03)**	**0.25***** **(3.17)**
USdummy	-0.003 (-0.05)	0.002 (0.05)	-0.064* (-1.68)	-0.06** (-1.98)
EUdummy	-0.14 (-1.80)	-0.10 (-1.42)	-0.14*** (-2.89)	-0.10** (-2.18)
hedgeUS	-0.11 (-0.67)	-0.14 (-0.90)	0.076 (0.73)	0.05 (0.64)
hedgeEU	-0.024 (-0.17)	-0.03 (-0.24)	0.0195 (0.22)	0.005 (0.06)
constant	0.065 (0.49)	0.011 (0.09)	0.14 (2.09)	0.09 (1.36)

Table 7
Government Ownership Analysis

The table below represents the results of the analysis that examined the effects of government ownership in our earlier results. Columns 2 and 3 perform ordinary least squares (OLS R.) regressions with heteroskedastically adjusted standard errors on both the unadjusted and adjusted firm value and control variables. Columns 4 and 5 perform generalized least squares (GLS R.) regression with heteroskedastically adjusted standard errors on both the unadjusted and adjusted firm value and control variables. The dummy variable (GOVdummy) represents government ownership in excess of 20% of the total shares outstanding. The interaction variable (HedgeGOV) represents the combined effect of the hedging variable and government ownership on firm value. The "hedging" test variable represents the consumption of jet fuel hedged for privately owned major carriers. Asterisks above the parentheses represents significance levels; * is used for 10%, ** is used for 5% and *** is used for 1% significance levels. The numbers in brackets are critical t-values.

Dependent Variable Log of Tobin's Q				
	OLS R.	OLS R. Adj.	GLS R.	GLS R. Adj.
Observations	0.27	275	275	275
R^2	0.34	0.25		
Wald chi^2			101.57	92.41
Log(assets)	0.025*** (3.33)	0.02*** (2.97)	0.025*** (4.03)	0.02*** (3.69)
Leverage	0.000 (1.08)	0.0002 (1.35)	0.000 (0.67)	0.0001 (0.67)
RoA	0.28* (1.47)	0.34** (2.04)	0.28*** (2.47)	0.34 (2.77)
Hedge	-0.04 (-0.53)	-0.015 (-0.26)	-0.04 (-0.55)	-0.015 (-0.24)
CFO/Rev	0.51 (2.86)	0.44*** (3.16)	0.50*** (3.12)	0.45*** (3.14)
Capex/Rev	0.32* (1.85)	0.22 (1.51)	0.32*** (2.39)	0.22* (1.85)
Dividends	-0.006 (0.22)	0.014 (0.61)	0.005 (0.22)	-0.015 (0.64)
GOVdummy	-0.083* (-1.67)	-0.12 (-0.45)	-0.08** (-2.04)	-0.02 (-0.55)
HedgeGOV	-0.091 (-0.89)	-0.13 (-1.52)	-0.091 (-0.95)	-0.14 (-1.59)
Constant	-0.23*** (-2.8)	-0.22*** (-2.84)	-0.24*** (-3.29)	-0.22*** (-3.37)

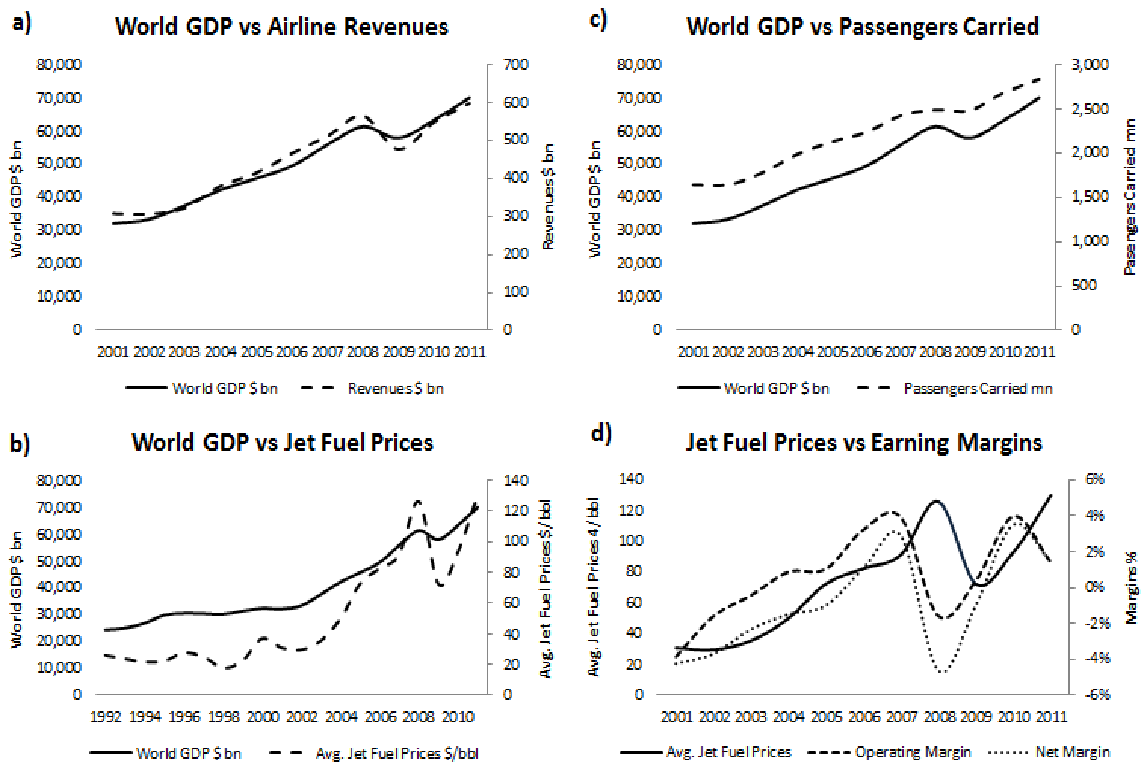

Figure 8: Implications of Global Economic Activity on Airline Industry Performance

Figure 8 demonstrates the relationships between jet fuel prices, passenger numbers, economic activity and earnings' margins. Graphs 8-a, 8-b and 1-c show the association between world GDP per year and total airline revenues, jet fuel prices and passenger numbers, respectively. Graph 8-d shows the sensitivity of profit margins (including transacion costs) to jet fuel prices. The increase in jet fuel costs is fuelled through two channels: 1) increases in spot jet fuel prices and 2) increases in fuel consumption through increased operating activity and capacity (measured by available seat kilometers).

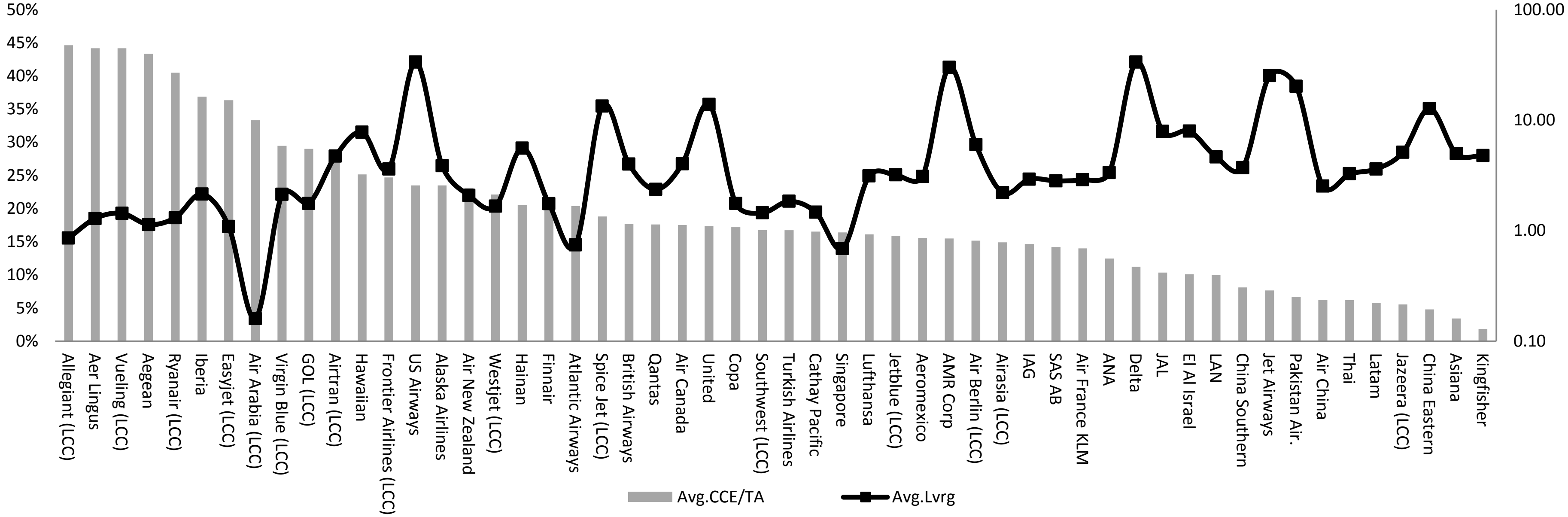

Figure 9: The Analysis of Cash Holdings and Financial Leverage

Figure 9 demonstrate the association between cash holdings (which include cash + cash equivalents) as a percentage of total assets and the level of financial leverage used for each of the sample airline companies. The grey bars, abbreviated as Avg.CCE/TA, are scaled to the left axis and represent the proportion of average cash and cash equivalents held in proportion to total assets. The straight black line, abbreviated as Avg.lvrg, is the average natural log of financial leverage and scaled to the right axis. Low cost carriers are identified as LCC. The figures are ordered from the highest level of CCE/TA holdings down. If we call the firms with the highest CCE/TA levels the most liquid firms, we observe that there are 7 low cost carriers among the top 10 most liquid airline companies. Additionally, 10 of the 16 low cost carriers in our sample are among the most liquid 20 airline companies in the whole sample. As expected, these low cost carriers also have the lowest level of financial leveage which graphically confirms our estimates in the univariate analysis (see Panel B of Table 2) that low cost carriers can be more sensitive to the level of internal cash funds than major carriers.

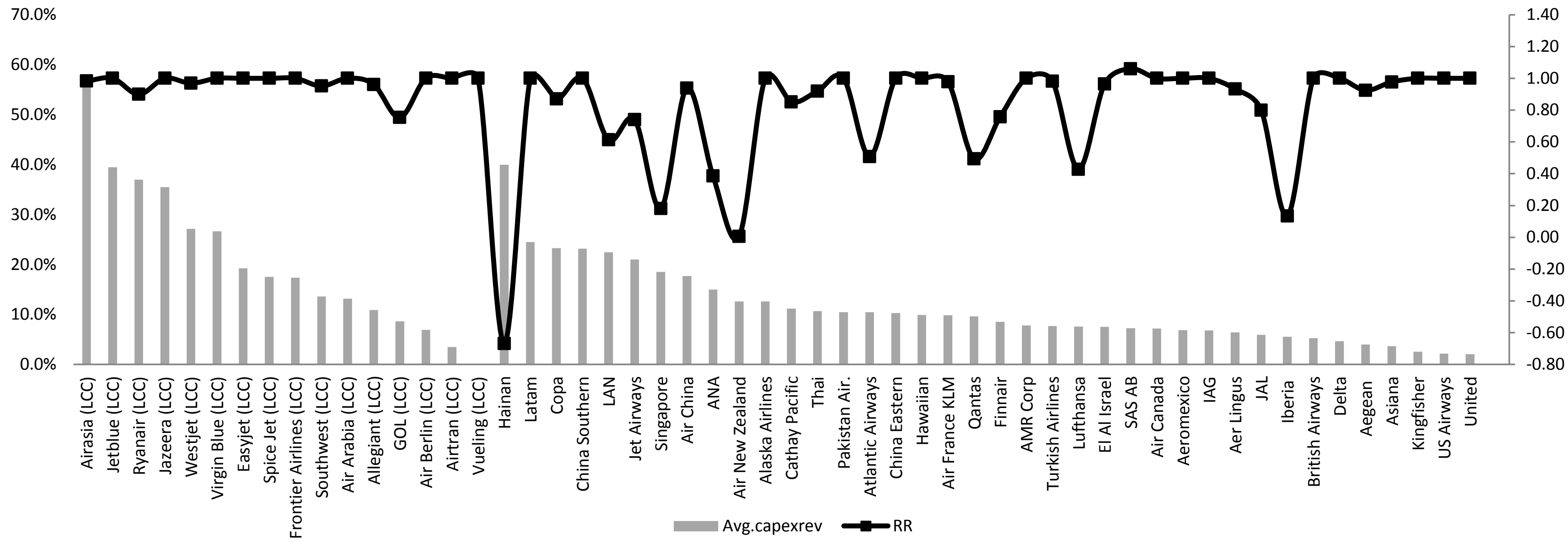

Figure 10: The Analysis of Retention Ratio and Capital Expenditures

The grey bars (avg.capexrev), scaled to the left hand side of the graph, indicate the level of capital expenditure as a percentage of revenue. The black line (RR), scaled to the right hand side of the graph, demonstrates the retention ratio estimated as $\left[1 - \left(\frac{Dividends\ per\ Share}{Earnings\ per\ Share}\right)\right]$. The first 13 airline companies are low cost carriers (LCC) and the remainder are all major carriers. The level of capital expenditure as a percentage of revenue is significantly greater for the low cost carriers. As expected, the retention ratio is much higher and more stable for the low cost carriers due to the fact that these airlines had to finance a greater scale of investments over the last decade. Additionally, low cost carriers lack implicit/explicit government support that some of the major carriers in our sample have enjoyed.

Table 8
Two-year Forward Curves for CIF NWE Jet Fuel

The table below shows an estimation of forward curves using the Pilipovic model (1998) which extends two years into the future. The first column shows contract months. From the second column to the final column, the table shows forward prices obtained using a 2-factor Pilipovic model.

	Forward Curves						
Months	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**
30	$422.19	$589.84	$620.77	$873.73	$470.00	$709.53	$834.65
60	$431.57	$602.30	$633.25	$859.42	$487.47	$725.35	$838.67
90	$438.80	$609.03	$640.58	$850.54	$501.35	$738.51	$841.10
120	$444.36	$612.67	$644.88	$845.03	$512.38	$749.44	$842.57
150	$448.65	$614.63	$647.41	$841.60	$521.14	$758.52	$843.46
180	$451.95	$615.69	$648.89	$839.48	$528.10	$766.08	$844.00
210	$454.49	$616.26	$649.76	$838.16	$533.63	$772.35	$844.32
240	$456.45	$616.57	$650.27	$837.34	$538.03	$777.57	$844.52
270	$457.95	$616.73	$650.57	$836.83	$541.51	$781.91	$844.64
300	$459.11	$616.82	$650.75	$836.52	$544.29	$785.51	$844.71
330	$460.01	$616.87	$650.85	$836.32	$546.49	$788.51	$844.75
360	$460.70	$616.90	$650.91	$836.20	$548.24	$790.99	$844.78
390	$461.23	$616.91	$6.95	$836.12	$549.63	$793.06	$844.80
420	$461.63	$616.92	$650.97	$836.08	$550.73	$794.78	$844.81
450	$461.95	$616.93	$650.98	$836.05	$551.61	$796.21	$844.81
480	$462.19	$616.93	$650.99	$836.03	$552.31	$797.40	$844.81
510	$462.38	$616.93	$650.99	$836.02	$552.86	$798.39	$844.82
540	$462.52	$616.93	$651.00	$836.01	$553.30	$799.21	$844.82
570	$462.63	$616.93	$651.00	$836.01	$553.65	$799.89	$844.82
600	$462.72	$616.93	$651.00	$836.00	$553.93	$800.46	$844.82
630	$462.78	$616.93	$651.00	$836.00	$554.15	$800.93	$844.82
660	$462.83	$616.93	$651.00	$836.00	$554.32	$801.32	$844.82
690	$462.87	$616.93	$651.00	$836.00	$554.46	$801.65	$844.82
720	$462.90	$616.93	$651.00	$836.00	$554.57	$801.92	$844.82

Table 9
Forward Price Adjusted Eurodollar Futures

The table below shows Eurodollar futures contracts adjusted for forward prices as of January the 1[st] of each year from 2005 to 2011. The first column displays the contract maturities extending for 4 years. From the second column to the last column, we present the adjusted prices of Eurodollar futures and their corresponding interest rates from 2005 to 2011.

Eurodollar Futures Contracts Adjusted for Forward Prices														
	2005		2006		2007		2008		2009		2010		2011	
CM	Price	Rate	Price	Rate	Price	Rate	Price	Rate	Price	Rate	Price	Rate	Price	Rate
Jan	$97.4	2.63%	$95.4	4.60%	$94.6	5.36%	$95.4	4.60%	$98.8	1.25%	$99.7	0.26%	$99.7	0.31%
Feb	$97.2	2.78%	$95.3	4.68%	$94.7	5.33%	$95.6	4.36%	$98.9	1.15%	$99.7	0.30%	$99.7	0.33%
Mar	$97.1	2.91%	$95.3	4.75%	$94.7	5.32%	$95.8	4.24%	$98.9	1.06%	$99.7	0.34%	$99.6	0.36%
Apr	$97.0	3.03%	$95.2	4.81%	$94.7	5.30%	$95.9	4.07%	$98.9	1.07%	$99.6	0.44%	$99.6	0.39%
May	$96.9	3.10%	$95.2	4.83%	$94.7	5.26%	$96.1	3.89%	$98.9	1.10%	$99.5	0.52%	$99.6	0.42%
Jun	$96.8	3.18%	$95.2	4.80%	$94.8	5.23%	$96.3	3.75%	$98.9	1.13%	$99.4	0.63%	$99.6	0.44%
Sep	$96.6	3.39%	$95.2	4.78%	$94.9	5.08%	$96.5	3.49%	$98.7	1.26%	$100.0	0.00%	$99.4	0.56%
Dec	$96.4	3.56%	$95.3	4.72%	$95.1	4.95%	$96.6	3.37%	$98.6	1.42%	$98.6	1.42%	$99.3	0.73%
Mar	$96.3	3.68%	$95.3	4.68%	$95.1	4.89%	$96.6	3.37%	$98.5	1.53%	$98.2	1.82%	$99.1	0.95%
Jun	$96.2	3.78%	$95.3	4.67%	$95.1	4.87%	$96.5	3.49%	$98.3	1.74%	$97.8	2.21%	$98.8	1.22%
Sep	$96.1	3.87%	$95.3	4.68%	$95.2	4.85%	$96.4	3.65%	$98.1	1.93%	$97.4	2.57%	$98.5	1.50%
Dec	$96.0	3.97%	$95.3	4.69%	$95.1	4.86%	$96.2	3.82%	$97.9	2.12%	$97.1	2.89%	$98.2	1.79%
Mar	$97.0	3.05%	$95.3	4.70%	$95.1	4.86%	$96.0	3.97%	$97.8	2.24%	$96.8	3.18%	$97.9	2.07%
Jun	$95.9	4.13%	$95.3	4.72%	$95.1	4.89%	$95.9	4.13%	$97.6	2.38%	$96.5	3.46%	$97.6	2.36%
Sep	$95.8	4.22%	$95.2	4.76%	$95.1	4.92%	$95.7	4.26%	$97.5	2.47%	$96.3	3.70%	$97.4	2.63%
Dec	$95.7	4.31%	$95.2	4.80%	$95.0	4.96%	$95.6	4.37%	$97.4	2.57%	$96.1	3.94%	$97.1	2.90%
Mar	$95.6	4.39%	$95.2	4.82%	$95.0	4.99%	$95.5	4.46%	$97.4	2.58%	$95.9	4.12%	$96.9	3.13%
Jun	$95.5	4.49%	$95.2	4.85%	$95.0	5.02%	$95.5	4.55%	$97.4	2.63%	$95.7	4.29%	$96.6	3.36%
Sep	$95.4	4.58%	$95.1	4.87%	$95.0	5.05%	$95.4	4.62%	$97.3	2.66%	$95.5	4.46%	$96.4	3.58%
Dec	$95.3	4.68%	$95.1	4.91%	$94.9	5.08%	$95.3	4.70%	$97.3	2.72%	$95.4	4.62%	$96.2	3.80%
Mar	$95.2	4.76%	$95.1	4.92%	$94.9	5.10%	$95.2	4.76%	$97.3	2.75%	$95.3	4.75%	$96.0	3.97%
Jun	$95.2	4.85%	$95.1	4.94%	$94.9	5.13%	$95.2	4.83%	$97.2	2.81%	$95.1	4.87%	$95.9	4.14%
Sep	$95.1	4.94%	$95.0	4.97%	$94.9	5.15%	$95.1	4.90%	$97.1	2.89%	$95.0	4.97%	$95.7	4.29%
Dec	$95.0	5.04%	$95.0	5.01%	$94.8	5.19%	$95.0	4.97%	$97.0	3.00%	$94.9	5.09%	$95.6	4.43%

Table 10
Two-year Spot Rate Curve

The table below shows spot rate curves obtained using bootstrapping from Eurodollar futures adjusted for forward prices from 2005 to 2011. The first column displays the contract maturities extending for 3 years.

	Spot Rate Curve						
	2005	2006	2007	2008	2009	2010	2011
1-MONTH	2.40%	4.39%	5.32%	4.60%	0.44%	0.23%	0.26%
2-MONTH	2.49%	4.48%	5.35%	4.65%	1.10%	0.24%	0.28%
3-MONTH	2.56%	4.54%	5.36%	4.70%	1.43%	0.25%	0.30%
4-MONTH	2.63%	4.59%	5.36%	4.68%	1.56%	0.29%	0.35%
5-MONTH	2.70%	4.65%	5.37%	4.63%	1.65%	0.35%	0.40%
6-MONTH	2.78%	4.70%	5.37%	4.59%	1.75%	0.43%	0.46%
7-MONTH	2.84%	4.73%	5.37%	4.56%	1.81%	0.51%	0.51%
8-MONTH	2.90%	4.76%	5.36%	4.45%	1.85%	0.62%	0.56%
9-MONTH	2.95%	4.78%	5.36%	4.38%	1.90%	0.71%	0.61%
10-MONTH	3.00%	4.80%	5.35%	4.32%	1.93%	0.80%	0.67%
11-MONTH	3.05%	4.82%	5.34%	4.27%	1.97%	0.89%	0.72%
12-MONTH	3.10%	4.84%	5.33%	4.22%	2.00%	0.78%	0.98%
13-MONTH	3.12%	4.85%	5.32%	4.17%	1.96%	0.82%	0.96%
14-MONTH	3.14%	4.85%	5.31%	4.12%	1.92%	0.86%	0.94%
15-MONTH	3.16%	4.86%	5.31%	4.08%	1.87%	0.90%	0.92%
16-MONTH	3.18%	4.87%	5.30%	4.05%	1.85%	0.95%	0.92%
17-MONTH	3.20%	4.87%	5.30%	4.02%	1.83%	0.99%	0.92%
18-MONTH	3.22%	4.88%	5.29%	3.99%	1.80%	1.04%	0.92%
19-MONTH	3.24%	4.88%	5.29%	3.97%	1.80%	1.09%	0.93%
20-MONTH	3.26%	4.89%	5.29%	3.96%	1.79%	1.15%	0.94%
21-MONTH	3.27%	4.90%	5.28%	3.94%	1.78%	1.20%	0.95%
22-MONTH	3.29%	4.90%	5.29%	3.94%	1.78%	1.25%	0.97%
23-MONTH	3.31%	4.91%	5.29%	3.94%	1.78%	1.31%	0.99%
24-MONTH	3.32%	4.92%	5.29%	3.94%	1.79%	1.36%	1.01%
25-MONTH	3.33%	4.93%	5.29%	3.94%	1.79%	1.42%	1.03%
26-MONTH	3.35%	4.94%	5.30%	3.95%	1.80%	1.47%	1.06%
27-MONTH	3.37%	4.94%	5.30%	3.96%	1.81%	1.53%	1.08%
28-MONTH	3.34%	4.95%	5.31%	3.97%	1.82%	1.58%	1.11%
29-MONTH	3.31%	4.96%	5.32%	3.98%	1.83%	1.64%	1.14%
30-MONTH	3.28%	4.97%	5.33%	3.99%	1.84%	1.69%	1.17%
31-MONTH	3.34%	4.98%	5.34%	4.01%	1.85%	1.74%	1.21%
32-MONTH	3.33%	4.99%	5.35%	4.02%	1.87%	1.79%	1.24%
33-MONTH	3.33%	5.00%	5.37%	4.05%	1.88%	1.85%	1.27%
34-MONTH	3.34%	5.01%	5.38%	4.06%	1.89%	1.90%	1.31%
35-MONTH	3.36%	5.03%	5.40%	4.08%	1.90%	1.95%	1.34%
36-MONTH	3.39%	5.04%	5.41%	4.10%	1.92%	2.00%	1.38%

Table 11
Asian Option Prices

The tables below shows call and put option premiums using different pricing methodologies. The first column in each panel indicates the time period examined. The second and the third columns show current market prices and the strike prices as of January the 1st each year. The fourth column shows whether the option is priced using strike prices equal to the observed spot prices (ATM) or strike prices which are equal to estimated swap prices (FV). The fifth column shows the estimated convenience yields. The sixth and the seventh columns show premiums for call and put options per metric tonnes of jet fuel. The final column shows that all the options are for a 1 year maturity.

Panel A: Average Price Asian Options ATM

	Price S(t)	Strike (K)	State	Conv. Yield	Call Price/USD MT	Put Price/USD MT	Duration
2005	$410.00	$410.00	ATM	6%	$31.89	$29.98	1-year
2006	$566.75	$566.75	ATM	-1%	$55.26	$33.49	1-year
2007	$599.50	$599.50	ATM	14%	$41.90	$50.55	1-year
2008	$896.75	$896.75	ATM	7%	$58.26	$67.47	1-year
2009	$448.00	$448.00	ATM	-29%	$115.00	$17.81	1-year
2010	$690.50	$690.50	ATM	-6%	$67.75	$46.58	1-year
2011	$828.00	$828.00	ATM	-11%	$94.98	$47.60	1-year

Panel B: Average Price Asian Options ATM

	Price S(t)	Strike (K)	*State*	Conv. Yield	Call Price/USD MT	Put Price/USD MT	Duration
2005	$410.00	$448.75	FV	6%	$16.51	$57.62	1-year
2006	$566.75	$625.78	FV	-1%	$29.28	$68.89	1-year
2007	$599.50	$644.80	FV	14%	$19.08	$93.97	1-year
2008	$896.75	$844.38	FV	7%	$82.00	$56.42	1-year
2009	$448.00	$522.58	FV	-29%	$40.75	$43.40	1-year
2010	$690.50	$766.74	FV	-6%	$36.10	$91.14	1-year
2011	$828.00	$842.68	FV	-11%	$87.25	$53.57	1-year

Panel C: Geometric Asian Options ATM - Kemna and Vorst (1990)

	Price S(t)	Strike (K)	State	Conv. Yield	Call Price/USD MT	Put Price/USD MT	Duration
2005	$410.00	$410.00	ATM	6%	$42.40	$20.30	1-year
2006	$566.75	$566.75	ATM	-1%	$70.80	$20.00	1-year
2007	$599.50	$599.50	ATM	14%	$45.50	$45.40	1-year
2008	$896.75	$896.75	ATM	7%	$66.50	$75.10	1-year
2009	$448.00	$448.00	ATM	-29%	$113.30	$15.00	1-year
2010	$690.50	$690.50	ATM	-6%	$70.90	$42.50	1-year
2011	$828.00	$828.00	ATM	-11%	$98.00	$42.20	1-year

Panel D: Geometric Asian Options ATM - Kemna and Vorst (1990)

	Price S(t)	Strike (K)	State	Conv. Yield	Call Price/USD MT	Put Price/USD MT	Duration
2005	$410.00	$448.75	FV	6%	$23.00	$44.10	1-year
2006	$566.75	$625.78	FV	-1%	$40.60	$45.90	1-year
2007	$599.50	$644.80	FV	14%	$26.00	$78.50	1-year
2008	$896.75	$844.38	FV	7%	$92.40	$49.20	1-year
2009	$448.00	$522.58	FV	-29%	$6.40	$133.20	1-year
2010	$690.50	$766.74	FV	-6%	$37.80	$85.70	1-year
2011	$828.00	$842.68	FV	-11%	$89.60	$48.50	1-year

Table 12
Operational Data and Estimated Fuel Consumption

	2005	2006	2007	2008	2009	2010	2011
ASK (millions)	29,805	36,934	41,619	46,343	56,574	65,100	81,193
RSK (millions)	21,317	25,383	30,251	34,265	40,130	47,950	58,933
Km. flown (thousands)	168,902	207,202	232,147	262,124	311,869	358,370	419,113
Rev. Passengers (millions)	14.13	16.95	19.64	22.60	25.10	29.12	32.65
Fuel Expenses (millions)	729.4	1106.6	1168.9	1850.7	1527.8	2161.7	3984.3
Est.Fuel Cons / ASK	0.0029%	0.0029%	0.0029%	0.0029%	0.0029%	0.0029%	0.0029%
Est. Fuel Cons (metric tons)	897,131	1,111,713	1,248,570	1,385,359	1,640,646	1,904,856	2,347,914
Fuel/OPEX	24%	28%	28%	33%	24%	27%	34%

Table 13
Fuel Cost Savings-Single Derivative Positions

The table below demonstrates the fuel cost savings for single derivative positions in panel A and for combination positions in panel B. The first column in panel A indicates the time period examined. The second and third columns estimate the fuel cost savings for swaps for 50% and 100% hedge ratios (H). The fourth column shows costs to acquire swap positions. The fifth and sixth columns estimate the fuel cost savings for Asian options for 50% and 100% hedge ratios and the seventh and eighth columns show premium costs related to these options for 50% and 100% hedge ratios. The ninth and tenth columns show the fuel costs saved using collar strategies for 50% and 100% hedge ratios. The final two columns show the cost of obtaining 50% and 100% hedge ratios using collar strategies. The first column in panel B indicates the time period examined. The second and the third columns estimate the fuel cost savings for participating collar strategies using 50% and 100% hedge ratios and the fourth and fifth columns show the cost of structuring participating collars. The sixth and seventh columns show the results of the four-way collar strategy and the final two columns show the upfront premium paid for 50% and 100% hedge ratios.

Panel A: FUEL COSTS SAVED: Single Derivative Positions (in millions)

	SWAPS			ASIAN				COLLAR			
	Fuel Costs Saved		Cost	Fuel Costs Saved		Cost 50%	Cost 100 %	Fuel Costs Saved		Cost 50%	Cost 100%
YEAR	50% H	100% H		50% H	100% H			50% H	100% H		
2005	$52	$104	$0	$45	$90	$7.4	$14.8	$36.8	$73.5	-$1.7	-$3.4
2006	$12.9	$26	$0	$2.1	$4.2	$16.3	$32.6	$5.7	$11.3	-$1.8	-$3.6
2007	$42	$84	$0	$38.4	$77	$11.9	$23.8	$35.5	$71	-$1.7	-$3,4
2008	$112.6	$225	$0	$91.5	$183	$56.8	$113	$67.6	$135	$26.8	$53.7
2009	$34.7	$69.4	$0	$17.1	$34.2	$35.6	$71	$15	$30.4	$12.9	$24.9
2010	-$41	-$82.6	$0	-$28.5	-$57	$34.3	$68.6	$0.476	$0.952	-$0.48	-0.952
2011	$203	$406	$0	$100.8	$201.5	$102	$204	$58.7	$117.5	$49.9	$99.9
Savings	$416.4	$832.8	$0	$266.4	$532.9	$264	$528	$219.9	$439.8	$83.7	$167

Panel B: FUEL COSTS SAVED: Single Derivative Positions (in millions)

	PART.COLLAR			four-way collars			
	Fuel Costs Saved		Cost	Fuel Costs Saved		Cost 50%	Cost 100%
YEAR	50% H	100% H		50% H	100% H		
2005	$33.67	$67.34	$0	$33.96	$67.92	$7.92	$15.84
2006	$18.94	$37.9	$0	$10.9	$21.8	-$3.43	-$6.9
2007	$47.2	$94.33	$0	$30.98	$61.96	-$7.99	-$15.99
2008	$79.8	$159.55	$0	$38.7	$77.4	$15.1	$30.2
2009	$19.9	$39.9	$0	$27.64	$55.3	$6.66	$13.3
2010	$20.1	$40.3	$0	$5.5	$11	-$3.65	-$7.3
2011	$106.5	$212.9	$0	$122.4	$244.7	$28.26	$56.5
Savings	$326.1	$652.2	$0	$185.49	$370.98	$42.85	$85.7

Table 14
Fuel Cost Savings-Combination Strategies

Panel A shows yearly fuel cost savings using combination strategies. The first column indicates the time period examined. The second and third columns show the fuel cost saved and the cost of protection for 50% swaps and 50% Asian option combination. The fourth and fifth columns show the fuel cost saved and the cost of protection for 50% swaps and 50% collar strategy combination. Similarly, in panel B, the first column indicates the time period examined. The second, third, fourth and fifth columns exhibit the fuel costs saved and the cost of protection for 50% swaps and 50% four-way collar and 50% swaps and 50% participating collar strategies, respectively.

Panel A: FUEL COSTS SAVED : Combinations

	50% SWAPS + 50% ASIAN Options		50% SWAPS + 50% COLLAR	
YEAR	Fuel Costs Saved (USD)	Cost of Protection	Fuel Costs Saved (USD)	Cost of Protection
2005	$97,316,763.70	$7,405,824.66	$62,905,103.09	-$1,689,299.56
2006	$16,935,174.48	$16,275,492.96	$19,862,255.47	-$1,783,189.26
2007	$74,169,934.62	$11,911,357.80	$72,085,578.60	-$8,353,932.16
2008	$90,941,255.38	$56,799,760.00	$157,628,260.63	$26,831,998.82
2009	$46,920,788.39	$35,602,018.20	$45,871,566.00	$12,491,550.51
2010	-$70,066,758.28	$34,382,650.80	-$41,170,485.84	-$476,214.00
2011	$302,744,626.79	$102,427,748.25	$260,458,773.82	$49,992,137.08
Savings	$558,961,785.08	$264,804,852.67	$577,641,051.77	$77,013,051.44

Panel B: FUEL COSTS SAVED : Combinations

	50% SWAPS + 50% 4-WAY COLLAR		50% SWAPS + 50% PART. COLLAR	
YEAR	Fuel Costs Saved (USD)	Cost of Protection	Fuel Costs Saved (USD)	Cost of Protection
2005	$77,274,184.34	-$1,007,927.80	$85,829,144.15	$0.00
2006	$20,287,739.06	-$1,715,013.39	$31,915,126.82	$0.00
2007	$67,123,424.29	-$3,998,358.14	$89,250,276.55	$0.00
2008	$145,091,707.54	$7,548,999.81	$192,421,669.68	$0.00
2009	$53,458,851.74	$3,327,599.23	$54,636,437.98	$0.00
2010	-$37,667,368.67	-$1,827,947.44	-$21,192,404.08	$0.00
2011	$276,335,875.98	$14,131,742.18	$309,656,088.97	$0.00
Savings	$601,904,414.28	$16,459,094.45	$742,516,340.07	$0.00

Table 15
Upper Tail Fuel Cost at Risk-Single Derivative Positions

Panel A analyses the fuel cost at risk analysis (FCaR). This estimates the maximum effective fuel costs the airline company might be exposed to using single derivative positions. The first column indicates the time period examined. The rest of the columns estimate the FCaR at 10% and 5% confidence levels for swaps, Asian options and collar strategies. Similarly, panel B shows the FCaR at 10% and 5% confidence levels for participating collars and four-way collars.

Panel A: FUEL COST at RISK UPPER TAIL ANALYSIS : Single Derivative Positions

	SWAPS		ASIAN		COLLAR	
	Fuel Cost at RISK		Fuel Cost at RISK		Fuel Cost at RISK	
YEAR	FCaR 10%	FCaR 5%	FCaR 10%	FCaR 5%	FCaR 10%	FCaR 5%
2005	$402,587,536	$402,587,536	$417,399,169	$417,399,169	$439,464,106	$439,464,106
2006	$695,688,387	$695,688,387	$728,239,373	$728,239,373	$761,688,624	$761,688,624
2007	$805,077,936	$805,077,936	$828,900,652	$828,900,652	$868,879,863	$868,879,863
2008	$1,169,243,840	$1,169,243,840	$1,282,843,360	$1,282,843,360	$1,340,668,286	$1,340,668,286
2009	$857,368,787	$857,368,787	$928,572,823	$928,572,823	$968,092,704	$968,092,704
2010	$1,460,529,289	$1,460,529,289	$1,529,294,591	$1,529,294,591	$1,605,629,790	$1,605,629,790
2011	$1,978,540,170	$1,978,540,170	$2,183,395,666	$2,183,395,666	$2,276,368,365	$2,276,368,365
Total FCaR	$7,369,035,945	$7,369,035,945	$7,898,645,634	$7,898,645,634	$8,260,791,738	$8,260,791,738

Panel B: FUEL COST at RISK UPPER TAIL ANALYSIS : Single Derivative Positions

	PART.COLLAR		Four-way collars	
	Fuel Cost at RISK		Fuel Cost at RISK	
YEAR	FCaR 10%	FCaR 5%	FCaR 10%	FCaR 5%
2005	$442,873,204	$442,873,204	$642,967,956	$668,311,907
2006	$765,257,281	$765,257,281	$859,313,010	$910,451,854
2007	$885,585,730	$885,585,730	$1,071,236,352	$1,113,375,590
2008	$1,150,188,213	$1,286,999,440	$1,893,539,833	$1,965,232,213
2009	$943,105,665	$943,105,665	$1,225,112,861	$1,272,691,595
2010	$1,606,582,218	$1,606,582,218	$1,678,464,817	$1,745,134,777
2011	$2,176,394,186	$2,231,152,237	$3,084,039,980	$3,202,022,659
Total FCaR	$7,969,986,498	$8,161,555,775	$10,454,674,810	$10,877,220,595

Table 16
Upper Tail Fuel Cost at Risk-Combination Strategies

Panel A analyses the upper tail fuel cost at risk analysis (FCaR) which estimates the maximum effective fuel costs the airline company might be exposed to using combination strategies. The first column indicates the time period examined. The rest of the columns estimate the FCaR at 10% and 5% confidence levels for 50% swaps combined with 50% Asian options, 50% collar strategies. Similarly, panel B shows the FCaR at 10% and 5% confidence levels for 50% swaps combined with 50% participating collar and 50% four-way collar strategies.

Panel A: FUEL COST at RISK UPPER TAIL ANALYSIS : Combinations

	50% SWAPS + 50% ASIAN Options		50% SWAPS + 50% COLLAR	
	Fuel Cost at RISK		Fuel Cost at RISK	
YEAR	FCaR 10%	FCaR 5%	FCaR 10%	FCaR 5%
2005	$409,993,353	$409,993,353	$421,025,821	$421,025,821
2006	$711,963,880	$711,963,880	$728,688,505	$728,688,505
2007	$816,989,294	$816,989,294	$836,978,900	$836,978,900
2008	$1,226,043,600	$1,226,043,600	$1,254,956,063	$1,254,956,063
2009	$892,970,805	$892,970,805	$912,730,745	$912,730,745
2010	$1,494,911,940	$1,494,911,940	$1,533,079,540	$1,533,079,540
2011	$2,080,967,918	$2,080,967,918	$2,127,454,267	$2,127,454,267
FCaR	$7,633,840,789	$7,633,840,789	$7,814,913,841	$7,814,913,841

Panel B: FUEL COST at RISK UPPER TAIL ANALYSIS : Combinations

	50% SWAPS + 50% 4-WAY COLLAR		50% SWAPS + 50% PART. COLLAR	
	Fuel Costs Saved (TRY)		Fuel Costs Saved (TRY)	
YEAR	FCaR 10%	FCaR 5%	FCaR 10%	FCaR 5%
2005	$522,777,746	$535,449,722	$422,730,370	$422,730,370
2006	$777,500,699	$803,070,121	$730,472,834	$730,472,834
2007	$938,157,144	$959,226,763	$845,331,833	$845,331,833
2008	$1,531,391,837	$1,567,238,027	$1,228,121,640	$1,228,121,640
2009	$1,041,240,824	$1,065,030,191	$900,237,226	$900,237,226
2010	$1,569,497,053	$1,602,832,033	$1,533,555,754	$1,533,555,754
2011	$2,531,290,075	$2,590,281,414	$2,077,467,178	$2,104,846,203
FCaR	$8,911,855,377	$9,123,128,270	$7,737,916,835	$7,765,295,860

Table 17
Lower Tail Fuel Cost at Risk-Single Derivative Positions

Panel A analyses the lower tail fuel cost at risk analysis (FCaR) which estimates the minimum effective fuel costs the airline company might be able to obtain using single derivative positions. The first column indicates the time period examined. The rest of the columns estimate the FCaR at 10% and 5% confidence levels for swaps, Asian options and collar strategies. Similarly, panel B shows the FCaR at 10% and 5% confidence levels for participating collar and four-way collar strategies.

Panel A: FUEL COST RISK LOWER TAIL ANALYSIS : Single Derivative Positions

	SWAPS		ASIAN		COLLAR	
	Fuel Cost at RISK		Fuel Cost at RISK		Fuel Cost at RISK	
YEAR	FCaR 10%	FCaR 5%	FCaR 10%	FCaR 5%	FCaR 10%	FCaR 5%
2005	$402,587,536	$402,587,536	$316,696,214	$291,352,264	$318,687,845	$318,687,845
2006	$695,688,387	$695,688,387	$451,667,164	$417,204,030	$552,982,108	$552,982,108
2007	$805,077,936	$805,077,936	$538,857,841	$496,718,603	$627,356,482	$627,356,482
2008	$1,169,243,840	$1,169,243,840	$984,298,280	$912,605,900	$989,684,560	$989,684,560
2009	$857,368,787	$857,368,787	$650,352,074	$602,773,340	$710,777,067	$710,777,067
2010	$1,460,529,289	$1,460,529,289	$878,329,102	$811,659,142	$1,167,471,004	$1,167,471,004
2011	$1,978,540,170	$1,978,540,170	$1,638,256,994	$1,520,274,315	$1,682,806,314	$1,682,806,314
FCaR	$7,369,035,945	$7,369,035,945	$5,458,457,668	$5,052,587,594	$6,049,765,378	$6,049,765,378

Panel B: FUEL COST RISK LOWER TAIL ANALYSIS : Single Derivative Positions

	PART.COLLAR		Four-way collars	
	Fuel Cost at RISK		Fuel Cost at RISK	
YEAR	FCaR 10%	FCaR 5%	FCaR 10%	FCaR 5%
2005	$370,766,300	$358,094,324	$257,650,192	$257,650,192
2006	$508,470,246	$491,238,679	$445,337,398	$445,337,398
2007	$588,263,756	$567,194,137	$507,307,226	$507,307,226
2008	$1,083,690,933	$1,047,844,743	$790,546,679	$790,546,679
2009	$712,327,477	$688,538,110	$570,600,108	$570,600,108
2010	$1,086,948,931	$1,053,613,951	$847,635,204	$847,635,204
2011	$1,921,814,567	$1,862,823,228	$1,342,578,079	$1,342,578,079
FCaR	$6,272,282,210	$6,069,347,172	$4,761,654,886	$4,761,654,886

Table 18
Lower Tail Fuel Cost at Risk-Combination Strategies

Panel A analyses the lower tail fuel cost at risk analysis (FCaR) which estimates the minimum effective fuel costs the airline company might be able to obtain using combination strategies. The first column indicates the time period examined. The rest of the columns estimate the FCaR at 10% and 5% confidence levels for 50% swaps combined with 50% Asian options, 50% collar strategies. Similarly, panel B shows the FCaR at 10% and 5% confidence levels for participating collar and four-way collar strategies.

Panel A: FUEL COST RISK LOWER TAIL ANALYSIS : Combinations

	50% SWAPS + 50% ASIAN Options		50% SWAPS + 50% COLLAR	
	Fuel Cost at RISK		Fuel Cost at RISK	
YEAR	FCaR 10%	FCaR 5%	FCaR 10%	FCaR 5%
2005	$359,641,875	$346,969,900	$360,637,691	$360,637,691
2006	$573,677,775	$556,446,208	$624,335,247	$624,335,247
2007	$671,967,888	$650,898,270	$716,217,209	$716,217,209
2008	$1,076,771,060	$1,040,924,870	$1,079,464,200	$1,079,464,200
2009	$753,860,431	$730,071,064	$784,072,927	$784,072,927
2010	$1,169,429,196	$1,136,094,216	$1,314,000,146	$1,314,000,146
2011	$1,808,398,582	$1,749,407,242	$1,830,673,242	$1,830,673,242
Total FCaR	$6,413,746,807	$6,210,811,769	$6,709,400,662	$6,709,400,662

Panel B: FUEL COST RISK LOWER TAIL ANALYSIS : Combinations

	50% SWAPS + 50% 4WAY COLLAR		50% SWAPS + 50% PART. COLLAR	
	Fuel Cost at RISK		Fuel Cost at RISK	
YEAR	FCaR 10%	FCaR 5%	YEAR	FCaR 10%
2005	$330,118,864	$330,118,864	$386,676,918	$380,340,930
2006	$570,512,892	$570,512,892	$602,079,317	$593,463,533
2007	$656,192,581	$656,192,581	$696,670,846	$686,136,036
2008	$979,895,260	$979,895,260	$1,126,467,387	$1,108,544,292
2009	$713,984,447	$713,984,447	$784,848,132	$772,953,448
2010	$1,154,082,247	$1,154,082,247	$1,273,739,110	$1,257,071,620
2011	$1,660,559,124	$1,660,559,124	$1,950,177,368	$1,920,681,699
Total FCaR	$6,065,345,416	$6,065,345,416	$6,820,659,077	$6,719,191,559

Table 19
Hedging Effectiveness using Upper Tail Fuel Cost at Risk

Panel A and B estimate the hedging effectiveness (HE) with upper tail FCaR in the denominator given by "Fuel Costs Saved (in USD) / Fuel Cost at Risk". The first columns in both panels indicate the time period examined. The final three rows exhibit the mean, median and standard deviation of the HE ratio in both panels. The second and third columns in panel A show the HE ratio for swaps; the fourth and fifth columns show the HE ratio for Asian options; the sixth and seventh columns show the HE ratio for collar strategy; the eighth and ninth columns are the HE ratio for participating collars and the final two columns are the HE ratio for four-way collars for 10% and 5% confidence intervals, respectively. Similar to panel A, from the second column to the final column, panel B exhibit the HE ratio for combinations of 50% swaps and 50% Asian options, 50% collar strategy, 50% four-way collar and 50% participating collar strategy for 10% and 5% confidence intervals, respectively.

Panel A: EFFECTIVE FUEL COSTS vs. UPPER TAIL FUEL COST at RISK : Single Derivative Positions

	SWAPS		ASIAN		COLLAR		PART.COLLAR		Four-way collars	
	Fuel Savings/FCaR		Fuel Savings/FCaR		Fuel Savings/FCaR		Fuel Savings/FCaR		Fuel Savings/FCaR	
YEAR	10%	5%	10%	5%	10%	5%	10%	5%	10%	5%
2005	26%	26%	22%	22%	17%	17%	15%	15%	8%	8%
2006	4%	4%	1%	1%	1%	1%	5%	5%	2%	2%
2007	10%	10%	9%	9%	8%	8%	11%	11%	5%	4%
2008	19%	19%	14%	14%	10%	10%	14%	12%	3%	3%
2009	8%	8%	4%	4%	3%	3%	4%	4%	3%	3%
2010	-6%	-6%	-4%	-4%	0%	0%	3%	3%	0%	0%
2011	21%	21%	9%	9%	5%	5%	10%	10%	5%	5%
Mean	12%	12%	8%	8%	6%	6%	9%	8%	4%	4%
Med.	10%	10%	9%	9%	5%	5%	10%	10%	3%	3%
Stdev	10%	10%	8%	8%	5%	5%	5%	4%	2%	2%

Panel B: EFFECTIVE FUEL COSTS vs. UPPER TAIL FUEL COST at RISK : Combinations

	50% SWAPS + 50% ASIAN Options		50% SWAPS + 50% COLLAR		50% SWAPS + 50% 4-WAY COLLAR		50% SWAPS + 50% PART. COLLAR	
	Fuel Savings/FCaR		Fuel Savings/FCaR		Fuel Savings/FCaR		Fuel Savings/FCaR	
YEAR	10%	5%	10%	5%	10%	5%	10%	5%
2005	24%	24%	15%	15%	15%	14%	21%	21%
2006	2%	2%	3%	3%	3%	3%	2%	2%
2007	9%	9%	9%	9%	7%	7%	5%	5%
2008	7%	7%	13%	13%	9%	9%	14%	14%
2009	5%	5%	5%	5%	5%	5%	5%	5%
2010	-5%	-5%	-3%	-3%	-2%	-2%	-3%	-3%
2011	15%	15%	12%	12%	11%	11%	15%	15%
Mean	8%	8%	8%	8%	7%	7%	8%	8%
Med.	7%	7%	9%	9%	7%	7%	5%	5%
Stdev	8%	8%	6%	6%	5%	5%	8%	8%

Table 20
Hedging Effectiveness using Lower Tail Fuel Cost at Risk-Single Derivative Positions

Panel A and B estimate the hedging effectiveness (HE) for single derivative positions with lower tail FCaR in the denominator given by "Fuel Costs Saved (in USD) / Fuel Cost at Risk". The first columns in both panels indicate the time period examined. The final three rows show the mean, median and standard deviation of the HE ratio in both panels. The second and third columns in panel A show the HE ratio for swaps; the fourth and fifth columns show the HE ratio for Asian options; the sixth and seventh columns show the HE ratio for collar strategy. The second and third columns in panel B show the HE ratio for participating collar and the final two columns show the HE ratio for four-way collars for 10% and 5% confidence intervals, respectively.

Panel A: EFFECTIVE FUEL COSTS vs. LOWER TAIL FUEL COST at RISK : Single Derivative Positions

	SWAPS		ASIAN		COLLAR	
	Fuel Savings/FCaR		Fuel Savings/FCaR		Fuel Savings/FCaR	
YEAR	FCaR 10%	FCaR 5%	FCaR 10%	FCaR 5%	FCaR 10%	FCaR 5%
2005	26%	26%	28%	31%	23%	23%
2006	4%	4%	1%	1%	2%	2%
2007	10%	10%	14%	15%	11%	11%
2008	19%	19%	19%	20%	14%	14%
2009	8%	8%	5%	6%	4%	4%
2010	-6%	-6%	-6%	-7%	0%	0%
2011	21%	21%	12%	13%	7%	7%
Mean	12%	12%	10%	11%	9%	9%
Median	10%	10%	12%	13%	7%	7%
Stdev	10%	10%	11%	12%	7%	7%

Panel B: EFFECTIVE FUEL COSTS vs. LOWER TAIL FUEL COST at RISK : Single Derivative Positions

	PART.COLLAR		Four-way collars	
	Fuel Savings/FCaR		Fuel Savings/FCaR	
YEAR	FCaR 10%	FCaR 5%	FCaR 10%	FCaR 5%
2005	18%	19%	19%	19%
2006	7%	8%	3%	3%
2007	16%	17%	10%	10%
2008	15%	15%	8%	8%
2009	6%	6%	7%	7%
2010	4%	4%	1%	1%
2011	11%	11%	11%	11%
Mean	11%	11%	8%	8%
Median	11%	11%	8%	8%
Stdev	5%	5%	6%	6%

Table 21
Hedging Effectiveness using Lower Tail Fuel Cost at Risk-Combination Strategies

Panel A and B estimate the hedging effectiveness (HE) for combination strategies with upper tail FCaR in the denominator given by "Fuel Costs Saved (in USD) / Fuel Cost at Risk". The first columns in both panels indicate the time period examined. The final three rows show the mean, median and standard deviation of the HE ratio in both panels. The second, third, fourth and fifth columns in panel A show the HE ratio for 50% swaps combined with 50% Asian options and collar strategies using 10% and 5% level of significance. Similarly, in panel A, the second, third, fourth and fifth columns in show the HE ratio for 50% swaps combined with 50% four-way collar and 50% participating collar strategies using 10% and 5% level of significance.

Panel A: EFFECTIVE FUEL COSTS vs. LOWER TAIL FUEL COST at RISK : Combinations

	50% SWAPS + 50% ASIAN Options		50% SWAPS + 50% COLLAR	
	Fuel Savings/FCaR		Fuel Savings/FCaR	
YEAR	FCaR 10%	FCaR 5%	FCaR 10%	FCaR 5%
2005	27%	28%	17%	17%
2006	3%	3%	3%	3%
2007	11%	11%	10%	10%
2008	8%	9%	15%	15%
2009	6%	6%	6%	6%
2010	-6%	-6%	-3%	-3%
2011	17%	17%	14%	14%
Mean	9%	10%	9%	9%
Median	8%	9%	10%	10%
Stdev	10%	10%	7%	7%

Panel B: EFFECTIVE FUEL COSTS vs. LOWER TAIL FUEL COST at RISK : Combinations

	50% SWAPS + 50% 4-WAY COLLAR		50% SWAPS + 50% PART. COLLAR	
	Fuel Savings/FCaR		Fuel Savings/FCaR	
YEAR	FCaR 10%	FCaR 5%	FCaR 10%	FCaR 5%
2005	23%	23%	22%	23%
2006	4%	4%	5%	5%
2007	10%	10%	13%	13%
2008	15%	15%	17%	17%
2009	7%	7%	7%	7%
2010	-3%	-3%	-2%	-2%
2011	17%	17%	16%	16%
Mean	10%	10%	11%	11%
Med.	10%	10%	13%	13%
Stdev	8%	8%	8%	8%

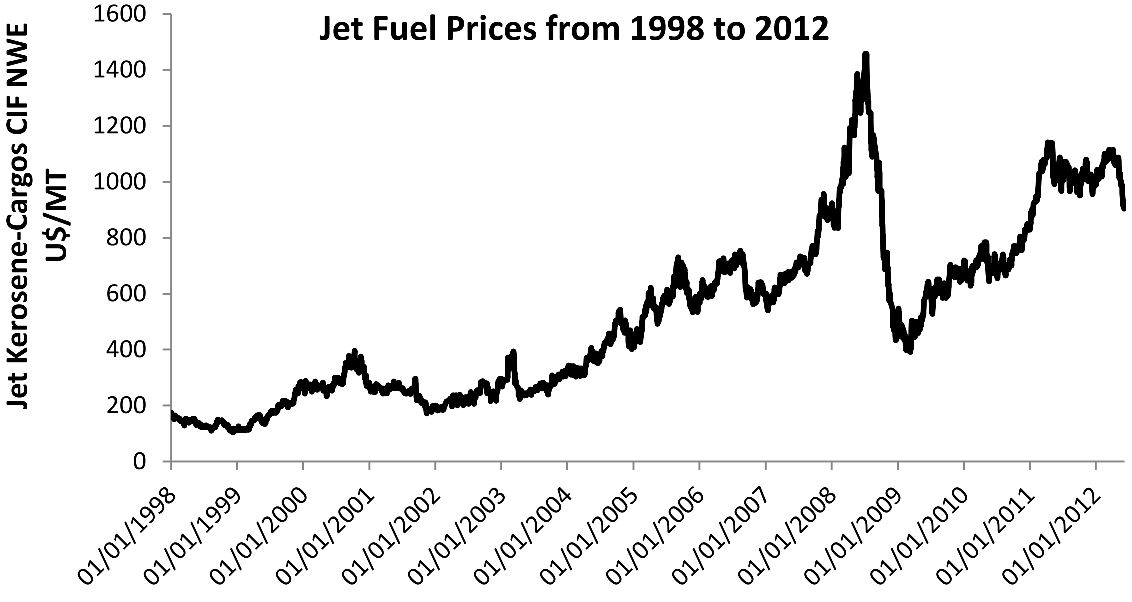

Figure 11: Jet Fuel Price History, Source: EIA

Table 22
Effective Fuel Costs and Fuel cost Savings

Panel A presents the results of total effective fuel costs in the domestic currency (TRY) in millions per metric tons of fuel consumed. Column 1 lists the hedging strategies used. Columns 2 to 8 display the fuel costs each strategy would generate. Panel B compares the effective fuel costs obtained and presented in Panel A with the fuel costs of Turkish Airlines. The first row presents the actual results of the actual fuel expenses of Turkish Airlines. The rows below that show the fuel cost advantage/disadvantage each hedging strategy provides compared to the fuel costs obtained by Turkish Airlines. The last column shows the aggregate fuel cost savings that could be obtained using these instruments. All data is in TRY millions per metric tons of fuel consumed.

Panel A: Total Effective Fuel Costs (TRY/millions per metric tons)

Hedging Strategy	2005	2006	2007	2008	2009	2010	2011
Swaps 50%	614	1,031	788	1,653	1,382	2,136	3,661
Swaps 100%	544	1,010	752	1,525	1,333	2,199	3,620
Asian 50%	624	1,047	1,101	1,671	1,407	2,116	3,833
Asian 100%	563	1,042	1,042	1,562	1,384	2,159	3,664
Collars 50%	635	1,042	1,103	1,702	1,409	2,073	3,904
Colars 100%	585	1,034	1,060	1,625	1,387	2,072	3,806
four-way collars 50%	651	1,040	1,116	1,741	1,403	2,068	3,879
four-way collars 100%	617	1,029	1,085	1,702	1,376	2,062	3,756
Part. Collars 50%	639	1,024	1,088	1,689	1,402	2,043	3,823
Part. Collars 100%	594	997	1,028	1,599	1,374	2,013	3,645

Panel B: Total Fuel Cost Savings (TRY/millions per metric tons)

Hedging Strategy	2005	2006	2007	2008	2009	2010	2011	T. Savings
THY Fuel Expenses	729	1,107	1,169	1,851	1,528	2,162	3,984	0
Fuel Cost Savings								
Swaps 50% Hedge	115	76	381	198	146	26	324	1,265
Swaps 100% Hedge	186	96	417	326	195	-37	364	1,546
Asian 50% Hedge	105	60	68	180	121	46	152	731
Asian 100% Hedge	166	64	126	289	144	3	320	1,113
Collars 50% Hedge	94	64	65	148	119	89	81	661
Colars 100% Hedge	144	73	109	226	141	90	178	960
four-way collars 50% Hedge	79	66	53	110	125	94	106	632
four-way collars 100% Hedge	113	77	84	148	152	99	228	902
Part. Collars 50% Hedge	90	82	81	162	125	118	161	820
Part. Collars 100% Hedge	136	109	141	252	154	148	339	1,279

Table 23
Operational Efficiency and Profitability Measures of Turkish Airlines

The table below presents the actual operating and profitability results from Turkish airlines. CASK gives the operating expenses per unit capacity measured by the available seat kilometres, FASK and FRSK are fuel costs per unit capacity and purchased portion of the available capacity measured by revenue seat kilometres respectively. OPEX/Passengers show the operating fuel costs per passenger carried. Fuel Costs/Passenger shows fuel costs per passenger carried. Operating costs also include fuel costs. The proportion of fuel costs in the total operating costs is measured by Fuel/OPEX. Net margin is the net income as a percentage of operating revenues.

	2005	2006	2007	2008	2009	2010	2011
CASK (OPEX / ASK)	10.11%	10.74%	10.16%	11.95%	11.16%	12.20%	14.43%
FASK (Fuel Costs / ASK)	2.45%	3.00%	2.81%	3.99%	2.70%	3.32%	4.91%
FRSK (Fuel Cost / RSK)	3.42%	4.36%	3.86%	5.40%	3.81%	4.51%	6.76%
OPEX/Passenger (TRY)	213	234	215	245	251	273	359
Fuel Cost / Passenger (TRY)	52	65	60	82	61	74	122
FCASK (Fuel Cost/CASK)	24.2%	27.9%	27.7%	33.4%	24.2%	27.2%	34.0%
Operating Revenues	2,953	3,812	4,522	6,123	7,036	8,423	11,815
Operating Costs	3,013	3,965	4,227	5,536	6,312	7,941	11,714
Fuel Expenses	729	1,107	1,169	1,851	1,528	2,162	3,984
Fuel/OPEX	24.2%	27.9%	27.7%	33.4%	24.2%	27.2%	34.0%
Net Income	138	179	282	1,139	558	303	-241
Net Margin	4.68%	4.69%	6.23%	18.60%	7.92%	3.59%	-2.04%

Table 24
Operational Efficiency and Profitability Measures of Turkish Airlines: Adjusted for Each Hedging Strategy

The table below reports the operating and profitability results of Turkish Airlines adjusted for fuel cost savings obtained using each derivative instrument. Each panel is for 50% hedging and is ordered in terms of the level of fuel costs saved. CASK gives the operating expenses per unit capacity measured by the available seat kilometres, FASK and FRSK are fuel costs per unit capacity and the purchased portion of the available capacity measured by revenue seat kilometres respectively. OPEX/Passengers shows operating fuel costs per passenger carried. Fuel Costs/Passenger shows fuel costs per passenger carried. Operating costs also include fuel costs. The proportion of fuel costs in the total operating costs is measured by Fuel/OPEX. Net margin is the net income as a percentage of operating revenues.

Panel A: SWAPS 50%

	2005	2006	2007	2008	2009	2010	2011
CASK (OPEX / ASK)	9.72%	10.53%	9.24%	11.52%	10.90%	12.16%	14.03%
FASK (Fuel Costs / ASK)	2.06%	2.79%	1.89%	3.57%	2.44%	3.28%	4.51%
FRSK (Fuel Cost / RSK)	2.88%	4.06%	2.61%	4.82%	3.44%	4.46%	6.21%
OPEX/Passenger (TRY)	205	229	196	236	246	272	349
Fuel Cost / Passenger (TRY)	43	61	40	73	55	73	112
FCASK (Fuel Cost/CASK)	21.2%	26.5%	20.5%	31.0%	22.4%	27.0%	32.1%
Operating Revenues (TRY)	2,953	3,812	4,522	6,123	7,036	8,423	11,815
Operating Costs (TRY)	2,898	3,889	3,846	5,338	6,166	7,915	11,391
Fuel Expenses (TRY)	614	1,031	788	1,653	1,382	2,136	3,661
Fuel/OPEX	21.2%	26.5%	20.5%	31.0%	22.4%	27.0%	32.1%
Net Income (TRY)	253	255	663	1,337	704	328	83
Net Margin	8.58%	6.68%	14.65%	21.83%	10.00%	3.90%	0.70%

Panel B: PARTICIPATING COLLARS 50%

	2005	2006	2007	2008	2009	2010	2011
CASK (OPEX / ASK)	9.81%	10.51%	9.96%	11.60%	10.94%	12.02%	14.23%
FASK (Fuel Costs / ASK)	2.14%	2.77%	2.61%	3.64%	2.48%	3.14%	4.71%
FRSK (Fuel Cost / RSK)	3.00%	4.03%	3.60%	4.93%	3.49%	4.26%	6.49%
OPEX/Passenger (TRY)	207	229	211	238	246	269	354
Fuel Cost / Passenger (TRY)	45	60	55	75	56	70	117
FCASK (Fuel Cost/CASK)	21.9%	26.4%	26.2%	31.4%	22.7%	26.1%	33.1%
Operating Costs (TRY)	2,923	3,882	4,145	5,374	6,186	7,822	11,553
Fuel Expenses (TRY)	639	1,024	1,088	1,689	1,402	2,043	3,823
Fuel/OPEX	21.9%	26.4%	26.2%	31.4%	22.7%	26.1%	33.1%
Net Income (TRY)	228	261	363	1,300	683	421	-80
Net Margin	7.73%	6.85%	8.03%	21.23%	9.71%	5.00%	-0.68%

Table 24 continued

Panel C: ASIAN OPTIONS 50%							
	2005	2006	2007	2008	2009	2010	2011
CASK (OPEX / ASK)	9.76%	10.57%	9.99%	11.56%	10.94%	12.13%	14.24%
FASK (Fuel Costs / ASK)	2.09%	2.83%	2.64%	3.61%	2.49%	3.25%	4.72%
FRSK (Fuel Cost / RSK)	2.93%	4.12%	3.64%	4.88%	3.51%	4.41%	6.50%
OPEX/Passenger (TRY)	206	230	212	237	247	271	354
Fuel Cost / Passenger (TRY)	44	62	56	74	56	73	117
FCASK (Fuel Cost/CASK)	21.5%	26.8%	26.5%	31.2%	22.7%	26.8%	33.2%
Operating Costs (TRY)	2,908	3,905	4,158	5,356	6,191	7,895	11,563
Fuel Expenses (TRY)	624	1,047	1,101	1,671	1,407	2,116	3,833
Fuel/OPEX	21.5%	26.8%	26.5%	31.2%	22.7%	26.8%	33.2%
Net Income (TRY)	244	239	350	1,319	678	348	-89
Net Margin	8.25%	6.26%	7.74%	21.54%	9.64%	4.13%	-0.76%

Panel D: COLLARS 50%							
	2005	2006	2007	2008	2009	2010	2011
CASK (OPEX / ASK)	9.79%	10.56%	10.00%	11.62%	10.95%	12.06%	14.33%
FASK (Fuel Costs / ASK)	2.13%	2.82%	2.65%	3.67%	2.49%	3.18%	4.81%
FRSK (Fuel Cost / RSK)	2.98%	4.11%	3.65%	4.97%	3.51%	4.32%	6.62%
OPEX/Passenger (TRY)	207	230	212	238	247	270	356
Fuel Cost / Passenger (TRY)	45	62	56	75	56	71	120
FCASK (Fuel Cost/CASK)	21.8%	26.7%	26.5%	31.6%	22.8%	26.4%	33.6%
Operating Costs (TRY)	2,919	3,901	4,161	5,387	6,193	7,851	11,634
Fuel Expenses (TRY)	635	1,042	1,103	1,702	1,409	2,073	3,904
Fuel/OPEX	21.8%	26.7%	26.5%	31.6%	22.8%	26.4%	33.6%
Net Income (TRY)	233	243	347	1,287	676	392	-160
Net Margin	7.87%	6.37%	7.68%	21.02%	9.61%	4.65%	-1.36%

Panel E: FOUR-WAY COLLARS 50%							
	2005	2006	2007	2008	2009	2010	2011
CASK (OPEX / ASK)	9.85%	10.56%	10.03%	11.71%	10.94%	12.05%	14.30%
FASK (Fuel Costs / ASK)	2.18%	2.82%	2.68%	3.76%	2.48%	3.18%	4.78%
FRSK (Fuel Cost / RSK)	3.05%	4.10%	3.69%	5.08%	3.50%	4.31%	6.58%
OPEX/Passenger (TRY)	208	230	213	240	246	269	356
Fuel Cost / Passenger (TRY)	46	61	57	77	56	71	119
FCASK (Fuel Cost/CASK)	22.2%	26.7%	26.7%	32.1%	22.7%	26.4%	33.4%
Operating Costs (TRY)	2,935	3,898	4,174	5,426	6,187	7,847	11,609
Fuel Expenses (TRY)	651	1,040	1,116	1,741	1,403	2,068	3,879
Fuel/OPEX	22.2%	26.7%	26.7%	32.1%	22.7%	26.4%	33.4%
Net Income (TRY)	217	245	335	1,248	682	396	-135
Net Margin	7.34%	6.43%	7.40%	20.39%	9.70%	4.71%	-1.15%

Table 25
IVF Analysis and Instrument Choice

The table below exhibits the IVF market sentiment strategy and instruments used. The first column shows the contract month used. The second column shows the difference between the third and fourth columns which show the implied volatilities for next month-to-expire and the current month, respectively. The fifth column shows the derivative instrument of choice as a result of the change in the implied volatilities of the far OTM put options shown in the second column. If the change is negative, futures are used whereas if the change is positive, options are used.

IVF Strategy and Instruments Used

Contract Month	OTM PUT IV	IV (t+1)	IV (t)	Instrument	Contract Month	OTM PUT IV	IV (t+1)	IV (t)	Instrument
Jan-06	-0.14	34.9%	35.0%	Futures	Jul-09	-2.33	52.3%	54.7%	Futures
Feb-06	-1.21	31.5%	32.7%	Futures	Aug-09	0.73	56.6%	55.9%	Options
Mar-06	-1.66	30.7%	32.4%	Futures	Sep-09	0.47	57.7%	57.2%	Options
Apr-06	-0.28	30.9%	31.2%	Futures	Oct-09	1.25	51.6%	50.4%	Options
May-06	-0.73	28.4%	29.1%	Futures	Nov-09	2.74	50.3%	47.5%	Options
Jun-06	0.73	28.3%	27.6%	Options	Dec-09	0.54	43.2%	42.7%	Options
Jul-06	-2.24	31.6%	33.8%	Futures	Jan-10	2.18	47.9%	45.7%	Options
Aug-06	-0.33	27.3%	27.6%	Futures	Feb-10	1.83	39.2%	37.3%	Options
Sep-06	-1.73	34.9%	36.7%	Futures	Mar-10	1.08	39.2%	38.1%	Options
Oct-06	-0.43	32.0%	32.4%	Futures	Apr-10	1.65	36.2%	34.5%	Options
Nov-06	-0.1	30.7%	30.8%	Futures	May-10	1.51	31.7%	30.2%	Options
Dec-06	1.19	27.4%	26.2%	Options	Jun-10	-2.86	45.2%	48.0%	Futures
Jan-07	-3.57	39.1%	42.7%	Futures	Jul-10	1.39	40.8%	39.4%	Options
Feb-07	-3.76	43.4%	47.2%	Futures	Aug-10	1.78	39.8%	38.0%	Options
Mar-07	-2.46	39.1%	41.6%	Futures	Sep-10	2.27	40.6%	38.3%	Options
Apr-07	1.82	34.4%	32.6%	Futures	Oct-10	2.46	38.9%	36.4%	Options
May-07	-1.41	29.6%	31.0%	Futures	Nov-10	0.56	38.2%	37.6%	Options
Jun-07	1.58	29.1%	27.5%	Options	Dec-10	1.3	37.2%	35.9%	Options
Jul-07	1.24	29.5%	28.3%	Options	Jan-11	0.92	33.6%	32.6%	Options
Aug-07	0.13	29.0%	28.8%	Options	Feb-11	1.83	39.2%	37.3%	Options
Sep-07	0.14	39.1%	39.0%	Options	Mar-11	3.25	31.6%	28.3%	Options
Oct-07	-1.59	31.6%	33.2%	Futures	Apr-11	3.8	44.2%	40.4%	Options
Nov-07	-4.55	29.3%	33.9%	Futures	May-11	2.07	31.9%	29.8%	Options
Dec-07	-1.52	31.3%	32.9%	Futures	Jun-11	5.74	42.1%	36.4%	Options
Jan-08	-0.93	31.9%	32.8%	Futures	Jul-11	5.82	36.4%	30.6%	Options
Feb-08	-0.82	29.9%	30.8%	Futures	Aug-11	1	37.0%	36.0%	Options
Mar-08	-0.83	31.0%	31.8%	Futures	Sep-11	10.53	51.4%	40.9%	Options
Apr-08	-1.98	37.9%	39.9%	Futures	Oct-11	12.66	54.6%	42.0%	Options
May-08	-3.85	37.0%	40.8%	Futures	Nov-11	9.33	55.4%	46.1%	Options
Jun-08	-1.72	39.1%	40.8%	Futures	Dec-11	11.5	51.5%	40.0%	Options
Jul-08	-1.24	47.4%	48.6%	Futures	Jan-12	7.95	46.7%	38.8%	Options
Aug-08	-1.72	54.0%	55.7%	Futures	Feb-12	3.61	40.8%	37.2%	Options
Sep-08	0.3	50.6%	50.3%	Options	Mar-12	0.7	35.3%	34.6%	Options
Oct-08	-3.85	50.6%	54.4%	Futures	Apr-12	2.56	34.4%	31.8%	Options
Nov-08	-9.2	72.9%	82.1%	Futures	May-12	0.97	31.6%	30.6%	Options

Table 25 continued

Dec-08	-6.61	78.9%	85.5%	Futures	Jun-12	-0.45	36.0%	36.5%	Futures
Feb-09	-6.65	77.7%	84.3%	Futures	Aug-12	1.54	37.0%	35.5%	Options
Mar-09	-11.04	71.7%	82.8%	Futures	Sep-12	2.61	33.9%	31.3%	Options
Apr-09	-5.45	77.2%	82.7%	Futures	Oct-12	2.16	38.6%	36.5%	Options
May-09	-4.26	65.3%	69.6%	Futures	Nov-12	2.11	36.7%	34.6%	Options
Jun-09	-3.2	56.3%	59.5%	Futures	Dec-12	1.1	31.0%	29.9%	Options

Table 26
The Results of the Futures Strategy

The table below shows the results of a simple roll-over strategy which only uses futures contracts. The first column lists the contract months traded, the second column shows the exact dates at which a prior month contract is rolled over to the next. The third and fourth columns show USD prices per barrel at which each futures contract is opened and closed. The fifth column show the number of contracts used for each trade. The sixth and seventh column show the notional amounts for each position opened and closed in USD millions. The final column is the pay-off in USD millions, or the difference between columns six and seven.

Rolling Over Futures Strategy

Contract Month	Pos. Enter-Close Dates	Pos. Closed (t)	Pos. Opened (t+1)	Contract Size	Open	Close	Pay-off
Jan-06	Beginning Contract =	February Contract	$63.14		$0.00	$0.00	**$3.39**
Feb-06	20/01/2006	$68.35	$68.48	100	$6.31	$6.84	-$0.52
Mar-06	17/02/2006	$59.88	$61.29	100	$6.85	$5.99	$0.86
Apr-06	20/03/2006	$60.42	$61.96	100	$6.13	$6.04	$0.09
May-06	19/04/2006	$72.17	$74.12	100	$6.20	$7.22	-$1.02
Jun-06	19/05/2006	$68.53	$69.29	100	$7.41	$6.85	$0.56
Jul-06	16/06/2006	$69.88	$70.20	100	$6.93	$6.99	-$0.06
Aug-06	18/07/2006	$71.14	$72.10	100	$7.02	$7.11	-$0.09
Sep-06	21/08/2006	$72.45	$73.30	100	$7.21	$7.25	-$0.04
Oct-06	19/09/2006	$61.66	$62.17	100	$7.33	$6.17	$1.16
Nov-06	19/10/2006	$58.50	$60.50	100	$6.22	$5.85	$0.37
Dec-06	17/11/2006	$55.81	$58.97	100	$6.05	$5.58	$0.47
Jan-07	15/12/2006	$63.43	$64.09	100	$5.90	$6.34	-$0.45
Feb-07	19/01/2007	$51.99	$53.40	100	$6.41	$5.20	$1.21
Mar-07	16/02/2007	$59.39	$59.86	100	$5.34	$5.94	-$0.60
Apr-07	16/03/2007	$57.11	$59.58	100	$5.99	$5.71	$0.28
May-07	20/04/2007	$63.38	$64.11	100	$5.96	$6.34	-$0.38
Jun-07	18/05/2007	$64.94	$65.98	100	$6.41	$6.49	-$0.08
Jul-07	19/06/2007	$69.10	$69.54	100	$6.60	$6.91	-$0.31
Aug-07	20/07/2007	$75.57	$75.79	100	$6.95	$7.56	-$0.60
Sep-07	17/08/2007	$71.98	$71.82	100	$7.58	$7.20	$0.38
Oct-07	18/09/2007	$81.51	$80.23	100	$7.18	$8.15	-$0.97
Nov-07	18/10/2007	$89.47	$88.00	100	$8.02	$8.95	-$0.92
Dec-07	14/11/2007	$94.09	$92.83	100	$8.80	$9.41	-$0.61
Jan-08	18/12/2007	$90.49	$90.08	100	$9.28	$9.05	$0.23
Feb-08	18/01/2008	$90.57	$89.92	100	$9.01	$9.06	-$0.05
Mar-08	19/02/2008	$100.01	$99.70	100	$8.99	$10.00	-$1.01
Apr-08	18/03/2008	$109.42	$108.50	100	$9.97	$10.94	-$0.97
May-08	18/04/2008	$116.69	$116.16	100	$10.85	$11.67	-$0.82
Jun-08	19/05/2008	$127.05	$126.72	100	$11.62	$12.71	-$1.09
Jul-08	20/06/2008	$134.62	$135.26	100	$12.67	$13.46	-$0.79
Aug-08	21/07/2008	$131.04	$131.82	100	$13.53	$13.10	$0.42
Sep-08	19/08/2008	$113.53	$114.54	100	$13.18	$11.35	$1.83
Oct-08	19/09/2008	$104.55	$102.75	100	$11.45	$10.46	$1.00
Nov-08	20/10/2008	$74.25	$74.39	100	$10.28	$7.43	$2.85
Dec-08	19/11/2008	$53.62	$54.10	100	$7.44	$5.36	$2.08
Jan-09	19/12/2008	$33.87	$42.36	100	$5.41	$3.39	$2.02

Table 26 continued

Feb-09	16/01/2009	$36.51	$42.57	100	$4.24	$3.65	$0.59
Mar-09	20/02/2009	$38.94	$40.03	100	$4.26	$3.89	$0.36
Apr-09	20/03/2009	$51.06	$52.07	100	$4.00	$5.11	-$1.10
May-09	20/04/2009	$45.88	$48.51	100	$5.21	$4.59	$0.62
Jun-09	18/05/2009	$59.03	$59.59	100	$4.85	$5.90	-$1.05
Jul-09	19/06/2009	$69.55	$70.02	100	$5.96	$6.96	-$1.00
Aug-09	20/07/2009	$63.98	$65.29	100	$7.00	$6.40	$0.60
Sep-09	19/08/2009	$72.42	$73.83	100	$6.53	$7.24	-$0.71
Oct-09	21/09/2009	$69.71	$69.93	100	$7.38	$6.97	$0.41
Nov-09	20/10/2009	$79.09	$79.12	100	$6.99	$7.91	-$0.92
Dec-09	20/11/2009	$76.72	$77.47	100	$7.91	$7.67	$0.24
Jan-10	18/12/2009	$73.36	$74.42	100	$7.75	$7.34	$0.41
Feb-10	19/01/2010	$79.02	$79.32	100	$7.44	$7.90	-$0.46
Mar-10	19/02/2010	$79.81	$80.06	100	$7.93	$7.98	-$0.05
Apr-10	19/03/2010	$80.68	$80.97	100	$8.01	$8.07	-$0.06
May-10	19/04/2010	$81.45	$83.13	100	$8.10	$8.15	-$0.05
Jun-10	18/05/2010	$69.41	$72.70	100	$8.31	$6.94	$1.37
Jul-10	21/06/2010	$77.82	$78.61	100	$7.27	$7.78	-$0.51
Aug-10	19/07/2010	$76.54	$76.90	100	$7.86	$7.65	$0.21
Sep-10	23/08/2010	$73.10	$73.73	100	$7.69	$7.31	$0.38
Oct-10	20/09/2010	$74.86	$76.19	100	$7.37	$7.49	-$0.11
Nov-10	19/10/2010	$79.49	$80.16	100	$7.62	$7.95	-$0.33
Dec-10	19/11/2010	$81.51	$81.98	100	$8.02	$8.15	-$0.14
Jan-11	17/12/2010	$88.02	$88.60	100	$8.20	$8.80	-$0.60
Feb-11	19/01/2010	$90.86	$91.81	100	$8.86	$9.09	-$0.23
Mar-11	18/02/2011	$86.20	$89.71	100	$9.18	$8.62	$0.56
Apr-11	21/03/2011	$102.33	$103.09	100	$8.97	$10.23	-$1.26
May-11	19/04/2011	$108.15	$108.25	100	$10.31	$10.82	-$0.51
Jun-11	20/05/2011	$99.49	$100.10	100	$10.83	$9.95	$0.88
Jul-11	20/06/2011	$93.26	$93.63	100	$10.01	$9.33	$0.68
Aug-11	19/07/2011	$97.50	$97.86	100	$9.36	$9.75	-$0.39
Sep-11	19/08/2011	$82.26	$82.41	100	$9.79	$8.23	$1.56
Oct-11	19/09/2011	$85.70	$85.81	100	$8.24	$8.57	-$0.33
Nov-11	19/10/2011	$86.11	$86.29	100	$8.58	$8.61	-$0.03
Dec-11	18/11/2011	$97.41	$97.67	100	$8.63	$9.74	-$1.11
Jan-12	19/11/2011	$93.88	$94.05	100	$9.77	$9.39	$0.38
Feb-12	17/01/2012	$100.71	$100.87	100	$9.41	$10.07	-$0.67
Mar-12	15/02/2012	$101.80	$102.14	100	$10.09	$10.18	-$0.09
Apr-12	15/03/2012	$105.11	$105.65	100	$10.21	$10.51	-$0.30
May-12	17/04/2012	$104.20	$104.64	100	$10.57	$10.42	$0.15
Jun-12	17/05/2012	$92.56	$92.94	100	$10.46	$9.26	$1.21
Jul-12	15/06/2012	$84.03	$84.00	100	$9.29	$8.40	$0.89
Aug-12	17/07/2012	$89.22	$89.54	100	$8.40	$8.92	-$0.52
Sep-12	16/08/2012	$95.60	$95.80	100	$8.95	$9.56	-$0.61
Oct-12	17/09/2012	$96.62	$96.95	100	$9.58	$9.66	-$0.08
Nov-12	17/10/2012	$92.12	$92.59	100	$9.70	$9.21	$0.48
Dec-12	13/11/2012	$85.38	$85.84	100	$9.26	$8.54	$0.72

Table 27
The Result of the IVF Strategy

The table below shows the results of the IVF strategy which uses futures contracts if/when the difference between the implied volatilities for the next-to-expire contract and the current month contract is negative and otherwise uses options. The first column lists the contract months traded. The second column shows the number of contracts used for each trade. The third and fourth columns show the strike and market prices at the initiation and close of trade dates at which a prior month contract is rolled over to the next. The third and fourth columns show USD prices per barrel at which each futures contract is opened and closed. The fifth, sixth and seventh columns show the notional amounts for each position opened and closed in USD millions. The final column is the pay-off in USD millions, the pay-off amount being the difference between columns six and seven.

IVF Hedging Strategy

Contract Month	Contract Size	Open Strike	Close Price	Option Cost	Option Pay-off	Futures Pay-off	IV Strategy Pay-off
Jan-06							
Feb-06	100				$0.00	$0.00	**-$9.40**
Mar-06	100	$70.16	$65.63	$0.38	$0.10	$0.90	$0.90
Apr-06	100	$65.63	$65.46	$0.17	-$0.20	$0.10	$0.10
May-06	100	$65.00	$75.89	$0.10	-$1.20	-$1.00	-$1.00
Jun-06	100	$76.00	$72.67	$0.16	$0.20	$0.60	$0.60
Jul-06	100	$72.00	$72.51	$0.10	-$0.20	-$0.10	-$0.10
Aug-06	100	$72.50	$77.44	$0.13	-$0.60	-$0.10	-$0.60
Sep-06	100	$77.50	$75.55	$0.18	$0.00	$0.00	$0.00
Oct-06	100	$75.50	$64.18	$0.12	$1.00	$1.20	$1.20
Nov-06	100	$64.00	$61.88	$0.15	$0.10	$0.40	$0.40
Dec-06	100	$62.00	$58.97	$0.14	$0.20	$0.50	$0.50
Jan-07	100	$59.00	$64.09	$0.18	-$0.70	-$0.40	-$0.40
Feb-07	100	$64.00	$58.75	$0.19	$0.30	$1.20	$0.30
Mar-07	100	$53.50	$62.62	$0.22	-$1.10	-$0.60	-$0.60
Apr-07	100	$59.00	$64.94	$0.24	-$0.80	$0.30	$0.30
May-07	100	$61.50	$68.75	$0.31	-$1.00	-$0.40	-$0.40
Jun-07	100	$64.68	$64.86	$0.21	-$0.20	-$0.10	-$0.10
Jul-07	100	$66.08	$68.00	$0.34	-$0.50	-$0.30	-$0.30
Aug-07	100	$68.73	$74.02	$0.21	-$0.70	-$0.60	-$0.70
Sep-07	100	$74.33	$71.00	$0.21	$0.10	$0.40	$0.10
Oct-07	100	$71.24	$80.57	$0.28	-$1.20	-$1.00	-$1.20
Nov-07	100	$79.65	$87.40	$0.25	-$1.00	-$0.90	-$1.00
Dec-07	100	$86.47	$91.17	$0.31	-$0.80	-$0.60	-$0.60
Jan-08	100	$90.00	$90.63	$0.30	-$0.40	$0.20	$0.20
Feb-08	100	$91.98	$90.84	$0.33	-$0.20	$0.00	$0.00
Mar-08	100	$90.68	$95.46	$0.30	-$0.80	-$1.00	-$1.00
Apr-08	100	$95.88	$110.21	$0.30	-$1.70	-$1.00	-$1.00
May-08	100	$109.49	$114.86	$0.45	-$1.00	-$0.80	-$0.80
Jun-08	100	$115.11	$124.12	$0.46	-$1.40	-$1.10	-$1.10
Jul-08	100	$124.66	$134.01	$0.53	-$1.50	-$0.80	-$0.80
Aug-08	100	$135.71	$129.29	$0.66	$0.00	$0.40	$0.40
Sep-08	100	$131.60	$113.77	$0.70	$1.10	$1.80	$1.80

Table 27 continued

Oct-08	100	$115.12	$97.16	$0.60	$1.20	$1.00	$1.00
Nov-08	100	$98.03	$69.85	$0.52	$2.30	$2.90	$2.30
Dec-08	100	$71.99	$54.95	$0.52	$1.20	$2.10	$2.10
Jan-09	100	$57.05	$43.60	$0.46	$0.90	$2.00	$2.00
Feb-09	100	$48.83	$37.28	$0.50	$0.70	$0.60	$0.60
Mar-09	100	$45.41	$34.93	$0.36	$0.70	$0.40	$0.40
Apr-09	100	$39.43	$49.16	$0.29	-$1.30	-$1.10	-$1.10
May-09	100	$51.18	$49.98	$0.38	-$0.30	$0.60	$0.60
Jun-09	100	$52.93	$58.62	$0.32	-$0.90	-$1.10	-$1.10
Jul-09	100	$60.12	$71.03	$0.34	-$1.40	-$1.00	-$1.00
Aug-09	100	$72.34	$62.02	$0.34	$0.70	$0.60	$0.60
Sep-09	100	$63.68	$66.75	$0.31	-$0.60	-$0.70	-$0.70
Oct-09	100	$69.50	$72.47	$0.36	-$0.70	$0.40	-$0.70
Nov-09	100	$73.44	$77.58	$0.29	-$0.70	-$0.90	-$0.70
Dec-09	100	$78.75	$79.14	$0.36	-$0.40	$0.20	-$0.40
Jan-10	100	$80.16	$72.66	$0.32	$0.40	$0.40	$0.40
Feb-10	100	$74.81	$79.39	$0.29	-$0.70	-$0.50	-$0.70
Mar-10	100	$80.27	$77.33	$0.31	$0.00	$0.00	$0.00
Apr-10	100	$78.05	$82.93	$0.27	-$0.80	-$0.10	-$0.80
May-10	100	$83.51	$85.51	$0.27	-$0.50	$0.00	-$0.50
Jun-10	100	$87.02	$70.08	$0.27	$1.40	$1.40	$1.40
Jul-10	100	$73.74	$76.79	$0.34	-$0.60	-$0.50	-$0.60
Aug-10	100	$78.35	$76.62	$0.26	-$0.10	$0.20	$0.20
Sep-10	100	$77.35	$75.77	$0.26	-$0.10	$0.40	-$0.10
Oct-10	100	$76.25	$74.57	$0.28	-$0.10	-$0.10	-$0.10
Nov-10	100	$76.01	$81.25	$0.28	-$0.80	-$0.30	-$0.80
Dec-10	100	$82.30	$82.34	$0.31	-$0.30	-$0.10	-$0.30
Jan-11	100	$83.16	$88.62	$0.28	-$0.80	-$0.60	-$0.80
Feb-11	100	$89.53	$91.40	$0.27	-$0.50	-$0.20	-$0.50
Mar-11	100	$92.83	$84.99	$0.26	$0.50	$0.60	$0.50
Apr-11	100	$88.12	$97.98	$0.27	-$1.30	-$1.30	-$1.30
May-11	100	$103.04	$107.11	$0.43	-$0.80	-$0.50	-$0.80
Jun-11	100	$109.11	$97.37	$0.36	$0.80	$0.90	$0.80
Jul-11	100	$97.94	$99.37	$0.37	-$0.50	$0.70	-$0.50
Aug-11	100	$95.75	$97.24	$0.31	-$0.50	-$0.40	-$0.50
Sep-11	100	$97.97	$86.65	$0.32	$0.80	$1.60	$0.80
Oct-11	100	$88.21	$88.91	$0.36	-$0.40	-$0.30	-$0.40
Nov-11	100	$88.73	$86.38	$0.38	-$0.10	$0.00	-$0.10
Dec-11	100	$89.10	$99.37	$0.38	-$1.40	-$1.10	-$1.40
Jan-12	100	$103.08	$93.87	$0.38	$0.50	$0.40	$0.50
Feb-12	100	$94.28	$100.71	$0.39	-$1.00	-$0.70	-$1.00
Mar-12	100	$101.23	$101.80	$0.34	-$0.40	-$0.10	-$0.40
Apr-12	100	$102.49	$105.11	$0.32	-$0.60	-$0.30	-$0.60

Table 27 continued

May-12	100	$105.96	$104.20	$0.30	-$0.10	$0.10	-$0.10
Jun-12	100	$104.92	$92.56	$0.29	$0.90	$1.20	$0.90
Jul-12	100	$93.26	$84.03	$0.31	$0.60	$0.90	$0.60
Aug-12	100	$84.76	$89.22	$0.31	-$0.80	-$0.50	-$0.50
Sep-12	100	$89.93	$95.60	$0.31	-$0.90	-$0.60	-$0.90
Oct-12	100	$96.24	$96.62	$0.32	-$0.40	-$0.10	-$0.40
Nov-12	100	$97.36	$92.12	$0.33	$0.20	$0.50	$0.20
Dec-12	100	$92.89	$85.38	$0.28	$0.50	$0.70	$0.50

Appendix 1: Excerpts from Regional Carriers' Annual Reports

Excerpt from Skywest 2010 SEC Filing:

"Our code-share agreements with Delta, United and Continental provide for fuel used in the performance of the code-share agreements to be reimbursed by our major partners, thereby reducing our exposure to fuel price fluctuations. United purchased fuel directly from fuel vendors for our United Express aircraft under contract operated out of Chicago, San Francisco, Los Angeles and Denver; Continental purchased all of the fuel for our Continental aircraft directly from Continental's fuel vendors; and as of June 1, 2009, Delta purchased the majority of the fuel for our Delta aircraft under contract directly from its fuel vendors. During the year ended December 31, 2010, approximately 76% of our fuel purchases were associated with our Delta and United code-share agreements and were reimbursed or paid directly by our major partners and approximately 24% of our fuel purchases were associated with our pro-rate operations."

Excerpt from Republic Airlines 2011 SEC Filing:

Fuel Hedging Transactions

Under our fixed-fee agreements we are not exposed to changes in fuel prices. Our fixed-fee agreements provide for our partners to purchase fuel directly or reimburse us for fuel expense as a pass through cost.

As of December 31, 2011, we did not have a hedge position. We will continue to monitor fuel prices closely and may take advantage of fuel hedging opportunities as they become available."

Appendix 2

Table 28
Government Ownership of Major Carriers

This table exhibits descriptive statistics for the major airline companies with government ownership equal to or exceeding 20% of the total shares outstanding. One exception in the table is Asiana airlines where the ownership ratio is 19% which is very close to the theoretical level at which a shareholder can exert significant influence. It should be noted that Asiana does not hedge its fuel consumption. Our results in the regression analyses in Table VIII are not affected by the addition and inclusion of Asiana. As a result, Asiana Airlines were left in the list. The first column lists the 12 airline companies with government ownership equal to or less than 20% of the total shares outstanding. The second column indicates the level of government ownership for each airline company. The third and fourth columns show the level of the next year's fuel consumption hedged and fuel costs as a percentage of operating expenses, respectively. The final column shows the firm value measured by the Q measure.

Airline Company	Hedge Ratio	Fuel/Opex	TBQ
Asiana	0%	35%	1.06
Aer Lingus	59%	24%	0.95
Air France	55%	22%	0.9
Thai Airways	36%	36%	0.99
Finnair	53%	21%	0.95
SAS AB	49%	17%	0.92
Turkish Airlines	5%	27%	1.07
Air New Zealand	58%	33%	0.95
Pakistan Airlines	0%	37%	1.1
Atlantic Airways	28%	36%	0.74
Air China	16%	36%	1.41
China Eastern	15%	34%	1.62
China Southern	0%	34%	1.03
Hainan	0%	35%	1.11
Aeromexico	50%	35%	1.38
min	0%	17%	0.74
mean	32%	34%	0.97
max	59%	37%	1.62
Standard Deviation	23%	7%	24%

Appendix 3

Appendix 3 examines the association between firm value and hedging using a categorical hedging variable which takes the value of one if the firm hedges and zero otherwise. The analysis in this appendix serves two main purposes. First, it enables one to take advantage of using the entire dataset. Firms that are excluded from the main analyses in the first element of this thesis are included in the regressions. These additional firms with insufficient hedging data, that is firms that do not disclose continuous hedging variable, increase the sample size to 476 firm-year observations. Noteworthy, however, dichotomous hedging variables convey significantly less information as to the true economic magnitude of airlines exposure to jet fuel prices. More precisely, it doesn't distinguish between the economic substances of hedging 5% of the consumption from hedging 90% of the consumption. This is a non-trivial shortcoming. Second, it tests the robustness of the analysis in the first element of this thesis that uses continuous hedging variables.[20]

The sample selection methodology which abolishes the requirement of continuous hedging variable results in 65 more firm-year observations. These additional 65 firm-year observations are comprised of six new firms; Aeroflot (Russia), Norwegian Air Shuttle (Norway); Malaysian Airlines (Malaysia), Korean Air Lines (South Korea), Croatia Airlines (Croatia) and finally Virgin Australia (Australia) and additional firm-year observations for the existing firms in the sample. It should be noted that Virgin Australia was formerly known as Virgin Blue which was a low cost carrier. The company transformed into a major carrier in March 2011. As a result, the data prior to the year 2011 are reported in the LCC sub-sample and the data during and after the year 2011 are reported in the MC sub-sample. In addition, the results in this section use unadjusted firm value proxy, Tobin's Q and control variables due to the limited disclosure on the use of off-balance sheet leases by these new companies. The dependent variable, Tobin's Q is calculated using Chung and Pruitt (1994) method that is used in the first element of this thesis. The values for the control variables are obtained from the Compustat Global database with a SIC code of 4512. The stock price data is obtained from DataStream to calculate Tobin's Q as a proxy measure of firm value.

[20] The analysis in this appendix is one of the many invaluable suggestions of Jon Tucker and Eirini Konstantinidi.

Panel A in Table 29 (below) uses hedging dummy variable, HedgeD as the test variable. Control variables used are the same as those used in the first element of this thesis. Columns 2 and 3 conduct ordinary least squares (OLS R.) and generalized least squares (GLS R.) regressions with standard deviations adjusted for heteroskedasticity. Using the total sample, both regressions suggest that hedging is irrelevant to firm value. Columns 4 and 5 have two additional dummy variables where lccdummy controls for whether an airline company is LCC or not HedgeLCC controls for the hedging of the LCCs. The variable HedgeD represents the hedging of the MCs'. The results indicate that LCCs' hedging is positively related to firm value, which confirm the findings in the first element of this thesis.

Panel B separates the sample into LCC and MC sub-samples. Columns 2 and 3 examine LCC sub-sample and columns 4 and 5 examine MC sub-sample. For the LCC sub-sample, the number of firm-year observations increased to 138 with the inclusion of Virgin Australia (Australia) for years 2009 and 2010. On the other hand, the number of firm-year observations increased to 338 for the MC sub-sample. For both sub-samples, Panel B use ordinary least squares (OLS R.) and generalized least squares (GLS R.) regressions with standard deviations adjusted for heteroskedasticity. In both regressions the hedging dummy variable, HedgeD, has no relation to firm value. Although these results confirm the findings for the MC sub-sample in the first element, they contradict with the findings for the LCC sub-sample. The findings for the LCC sub-sample are likely to be the result of undistinguished hedging levels of individual firms within the sub-sample. Given the degree of the sensitivity of airline cash flows to the variability and the level jet fuel price, inability to capture the degree of "actual" hedging will pool all hedging firms into the same category and won't reflect the economical and statistical differences between different hedging programs.

Table 29
Categorical Hedging Variable and Firm Value Analysis

Panel A and Panel B test for the association between firm value and hedging using a categorical identifier for the hedging variable. Columns 2 and 3 in Panel A present results of the hedging dummy variable, HedgeD, on the firm value dependent variable, Tobin's Q (unadjusted). Columns 4 and 5 assign a dummy variable, lccdummy, to control for-sample and interaction variable, HedgeLCC, which presents the hedging dummy variable for the LCC sub-sample. The variable, HedgeD, represents the hedging dummy variable for the MCs. Panel B separates the sample into LCC and MC sub-samples and test for the hedging and firm value relation for each group individually. Both panels use ordinary leas squares (OLS R.) and generalized least squares (GLS R.) regressions with standard deviations adjusted for heteroskedasticity. Asterisks above the parantheses represent significance levels: * is used for 10%, ** is used for 5% and *** is used for 1% significance levels. The numbers in brackets are t-values.

Panel A: Dependent Variable is Unadjusted Tobin's Q				
Total Sample				
	OLS R.	GLS R.	OLS R.	GLS R.
Observations	476	476	476	476
R^2	0.22		0.28	
Wald chi^2		147.90		143.5
Log(assets)	-0.016*** (-2.61)	-0.015*** (-2.64)	-0.00 (-1.38)	-0.00 (-1.48)
Leverage	0.00 (0.84)	0.00 (0.39)	0.00 (1.07)	0.00 (1.08)
RoA	1.11*** (3.18)	1.34*** (3.8)	0.45*** (3.32)	0.152*** (3.37)
HedgeD	**-0.045 (-1.09)**	**-0.04 (-1.04)**	**-0.08 (-1.25)**	**-0.08 (-1.20)**
CFO/Rev	0.41*** (3.34)	0.65*** (2.69)	0.29** (2.11)	0.29** (2.14)
Capex/Rev	0.47*** (5.46)	0.29*** (2.81)	0.38*** (4.43)	0.38*** (4.48)
Dividends	-0.02 (-0.94)	0.00 (0.13)	0.014 (0. 50)	-0.002 (0.51)
HIR	-0.05 (-0.30)	-0.05 (-1.24)	-0.15*** (-0.47)	-0.14 (-0.48)
HFXP	-0.07 (-1.23)	-0.08*** (-2.63)	-0.10*** (-3.47)	-0.10*** (-3.18)
lccdummy			0.05 (1.27)	0.05 (1.28)
HedgeLCC			0.26*** (3.16)	0.26*** (3.20)
Constant	0.33*** (5.14)	0.32*** (5.20)	0.25*** (3.50)	0.24*** (3.45)

Table 29 continued

Panel B: Dependent Variable is Unadjusted Tobin's Q				
	LCC Sample		MC Sample	
	OLS R.	GLS R.	OLS R.	GLS R.
Observations	138	138	338	338
R^2	0.22		0.15	
Wald chi^2		62		62
Log(assets)	-0.06*** (-2.66)	-0.06*** (-2.77)	0.00 (0.23)	0.00 (0.24)
Leverage	0.06 (1.63)	0.06* (1.69)	0.00 (0.96)	0.00 (0.98)
RoA	1.20*** (3.07)	1.19*** (3.19)	0.30** (2.35)	0.30*** (2.39)
HedgeD	**-0.06 (-0.92)**	**-0.07 (-0.96)**	**-0.04 (-1.15)**	**-0.04 (-1.17)**
CFO/Rev	0.41** (1.97)	0.65** (2.05)	0.29** (0.21)	0.29** (0.21)
Capex/Rev	0.30*** (2.36)	0.30*** (2.45)	0.38** (2.35)	0.38*** (2.39)
Dividends	-0.10 (-1.17)	-0.10 (-1.22)	0.04 (1.35)	0.05 (1.37)
HIR	-0.05 (-0.90)	-0.05 (-0.93)	-0.04 (-0.87)	-0.04 (-0.93)
HFXP	0.09 (0.46)	0.09 (-0.48)	-0.10 (-0.47)	-0.10 (-0.48)