Hedging Gone Wild: Was Delta Airlines' Purchase Of Trainer Refinery A Sound Risk Management Strategy?

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Abstract

In April 2012, Delta Airlines announced it would purchase the mothballed Trainer oil refinery in eastern Pennsylvania in order to secure access to a local supply of jet fuel and more broadly to incorporate the refinery's output into Delta's fuel hedging and risk management strategy. This unique vertical integration experiment was widely derided at the time, but we assess whether the policy has been value-enhancing over the four years since, and conclude it generally has been so. The purchase announcement generated positive abnormal returns in stock and bond markets. We confirm these results employing a relatively new econometric method, the synthetic control method. We also document that the default risk for Delta's bonds, proxied by CDS spread, dropped significantly at the purchase announcement and has continued trending down since then. After an unprofitable start-up period, Trainer has contributed significantly to Delta's operating profits and reduced its stock price exposure to crude oil and jet fuel price movements. Given the very small price Delta paid for the Trainer refinery–$150 million plus $270 million in subsequent capital investment and the fact that the benefits detailed above have accrued to Delta in both high and low oil-price regimes, we conclude this policy has proven beneficial.

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1. Introduction

Why would an airline ever choose to purchase and operate a petroleum refinery? Even though jet fuel is an airline's largest single cost, modern economic and management thought stresses that corporations should focus on their core business activities and purchase key inputs from efficient specialist suppliers. For the past four years, Delta Airlines has conducted a real-world test of the benefits of vertically integrating to lock in supplies of jet fuel and, more generally, to enhance the firms risk management and hedging strategy. This study assesses whether that strategy has been successful.

On April 30, 2012, Delta Airlines announced that its Monroe Energy subsidiary had entered into an agreement with Phillips 66 to acquire the Trainer oil refinery and related facilities in eastern Pennsylvania for $180 million (Lemer (2012)). Delta put up $150 million itself and the Commonwealth of Pennsylvania contributed the other $30 million. Before the acquisition, this refinery had been unprofitable for several years. Due to its dependence on expensive imported light crude oil and its inability to consistently meet tightening environmental and product standards, coupled with other severe problems plaguing all East Coast US refineries. Phillips 66 had shut the plant down in September 2011 (McCurty (2012)).

At the time the deal was announced, Delta argued that it was not so much trying to hedge its exposure to jet fuel prices, *per se*, but rather to hedge its exposure to refining profit margins, specifically the crack spread measuring the differentially higher valuations for jet fuel over the raw crude oil from which the fuel is processed. More comprehensively, Delta chose to purchase the refinery because of (1) widely fluctuating oil prices and the non-availability of a jet fuel hedging instrument; (2) Deltas poor hedging performance before 2012 and lack of expertise in using financial instruments for risk management; (3) the company's desire to capture the refining crack spread, which often reached $17 per barrel and had been rising steadily after oil prices rebounded from their early 2009 lows; and (4) Deltas need to secure jet fuel supplies for its New York City hubs–from which the company flew 68,000 departing flights every year–at a time when several East Coast refineries were being mothballed. The arrival of a high-powered energy hedging specialist, John Ruggles, as head of Delta's fuel hedging program in 2011, was another contributing factor, since it was said after his departure in summer 2012 that he drove the Trainer acquisition (Meyer (2013)).

Market reaction to the deal was dichotomous; most industry analysts and academic commentators derided the deal on industrial organizational grounds (why should an airline be able to competently run a refinery?), but other analysts and stock investors applauded the announcement, and the stock price rose by 3.5% on April 12, 2012, the day the rumor was announced (Massoudi (2012)), and then by over 5% around the official purchase announcement date of April 30, 2012 (Lemer, 2012). Although it was little noticed at the time, the purchase announcement also caused a sharp drop in Delta's perceived credit risk, proxied by CDS spreads on its outstanding bonds. Nor did uncertainty about the wisdom of the acquisition vanish in the years immediately following Delta's Trainer purchase, as described approvingly by Wright (2013), Hecht (2015), and Levine-Weinberg (2015b), but with opprobrium by Zhang (2014), Helman, and Dustin (2016).

The results of our empirical analyses confirm and extend those in Massoudi (2012) and Lemer (2012). We find that Delta's stock price experienced a positive cumulative abnormal return of 5.71% in the three days centered on the acquisition announcement. The bond market responded similarly but to a lesser extent; we find a mean abnormal return of 55 basis points for trades occurring over the ten days centered on the announcement date. Visual analysis of CDS trades confirms that the CDS market perceived the deal to be risk-reducing. We find evidence through panel regressions that Delta's exposure to oil prices, specifically the crack spread, declines in the post-acquisition period.

While the early assessment of Delta's wisdom in buying a refinery was mixed, there is no doubt about the early operating results, which were abysmal. Due largely to difficulties re-starting the mothballed refinery and making the complex off-take swap agreements work, in the first full quarter of operations, Trainer was loss-making and *increased* Delta's fuel bill by $63 million (Meyer (2013)). These teething problems continued, with varying severity, until early 2014. Unfortunately for Delta, lining out the refinery's operations, and negotiating a new swap agreement with Bridger LLC in July 2014 occurred immediately before the global price of crude oil (and jet fuel) began to crash in the fall of 2014. This resulted in severe losses on Delta's hedging portfolio that almost offset the benefit of declining fuel prices. Meanwhile, Delta's biggest rival, American Airlines Group--newly emerged from bankruptcy after merging with US Airways--abandoned hedging altogether mid-way through 2014 and thus profited massively as fuel prices declined by two-thirds between 3Q2014 and 4Q2015 (Maxon (2014) and Dustin (2016)). Delta finally bit the bullet in 2Q2015, canceling almost all remaining fuel hedges for 2H2015 and most of 2016, at a cost of $100-200 million per quarter (Levine-Weinberg (2015a)).

As was obvious to all concerned at the time of the purchase announcement, in order for Delta to economically operate a refinery, it would have to enter into a comprehensive swap program with a major oil company or trading firm to sell the 89% of refinery output that was not kerosene (jet fuel) and secure additional jet fuel supplies for other hubs not being serviced by Trainer. Delta would also need to acquire crude oil feedstock for the refinery. Before its closure in September 2011, Trainer had purchased crude from Nigeria and other foreign producers of light, sweet crude oil, but after the purchase Delta announced plans to partially switch to Bakken and other North American crudes and to increase Trainer's already high jet fuel production capacity (23,000 barrels per day, or bpd) over time to as much as 52,000 bpd by making at least $100 million in additional capital investment. By 2016, Delta had only partially achieved these goals (Dlouhy and Levine-Weinberg (2015a)).

This paper proceeds as follows. Section 2 summarizes the relevant literature on hedging and risk management (RM) and industrial organization-vertical integration. Section 3 describes the context that lead to the acquisition. In section 4, we discuss why Delta, and not any other airline, acquired the refinery. The empirical analysis starts in section 5, where we perform event studies of the stock and bond market reaction in section 5.1, and then study the channels through which Trainer may add value to Delta in section 5.2. Section 6 concludes.

2. Related Literature

Two principal streams of economic literature inform our analysis, and we discuss in turn below the implications drawn from the risk management and hedging literature in finance and the economic literature on industrial organization (IO) and vertical integration (VI). Both streams depart from the notion of perfect markets in the product market, for the case of IO, and in the capital market in the case of corporate hedging.

2.1. Predictions of the hedging and risk management literatures

Commodity markets have been the subject of many empirical studies on the value of hedging and characteristics of hedgers. These studies have reflected on the theoretical work on the determinants of risk management value. In general, theories assert that hedging can add value by reducing the likelihood of costly financial distress (Smith and Stulz (1985)); reducing the need for costly external financing (Froot, et al. (1993)); reducing the agency cost among managers, debt holders and equity holders, and benefiting from convexity in the cost structure (see Aretz and Bartram (2010) for an extensive review of these theories and the empirical support each receives).

Empirical studies of the value of hedging commodity risk are mixed. Carter et al. (2006) show that jet fuel hedging is positively related to airline firm value. Jin and Jorion (2006) study 119 oil and gas companies and find that hedging does reduce their exposure to oil and gas price risk, but does not affect their market values. MacKay and Moeller (2007) find that hedging concave revenues and convex costs is value enhancing; they document that their sample of 34 oil refiners could have increased their market values between 2% and 3% through hedging. Gilje and Taillard (2015) study Canadian oil companies, which experience a reduction in hedging effectiveness of WTI contracts relative to their U.S. counterparts after the unexpected breakdown in the correlation of Canadian light oil prices with the West Texas Intermediate (WTI) futures benchmark. They find that highly leveraged Canadian firms reduce investment, sell assets, and have lower valuations, consistent with theories predicting that hedging affects firm value by alleviating financial distress costs and underinvestment.

The airline industry has been the subject of numerous studies on the value of hedging and characteristics of hedgers. Carter, et al. (2006) document a 5% hedging premium in the airline industry and conclude that this hedging premium is in line with the Froot, et al. (1993) prediction that airlines hedge to offset the underinvestment problem potentially faced by airlines when fuel prices rise. With higher fuel prices, un-hedged firms will not be able to take positive NPV projects and thus will lose some potential value. On the other hand, Rampini, et al. (2014) show that, contrary to what existing theories predict, airlines in distress states hedge less; airlines with higher net worth, cash flow, or credit ratings hedge more; and hedging drops sharply as airlines approach distress and recovers thereafter. Explaining this behavior, they show that collateral requirements in both hedging (margin requirement) and financing result in a trade-off between hedging and financing that only firms with high net worth can accommodate. Treanor, et al. (2014) link time-varying exposure of airlines to fuel cost with hedging behavior and firm value. They find that firms hedge more when they experience a greater degree of exposure to fuel prices. Although they find a hedging premium, as shown in Carter, et al. (2006), they find evidence that the hedging premium does not increase with airline exposure to fuel prices, an indication that investors do not value selective hedging (Adam and Fernando (2006) discuss selective hedging and firm value).

2.2. Predictions of the industrial organization and vertical integration literature

Many articles have examined the costs and benefits of vertical integration (VI) in the context of acquiring a key supplier, both theoretically and with empirical analyses (see Perry (1989), Kedia et al. (2011), and Lafontaine and Slade (2007) for reviews). The industrial organization (IO) literature asserts that--in the presence of imperfect competition characterized by the possibility of rationing, shutting out of competitors, elimination of externalities, and the possibility of exclusive contracts and price discrimination–firms can generate value through VI. Such factors thoroughly characterize the airline industry. Because substantial outlays for capital and technology are required to efficiently operate an airline, barriers to entry are extremely high (Shepherd (1984)). The result is an airline industry which, in the United States, can be considered an oligopoly (Berry, 1990), and in many other countries a near monopoly. Further, the various classes of airline customers (Business, First, Economy, etc.) represent an ideal setting in which to implement price discrimination (Stavins (2001)).

A large body of empirical research area has offered considerable support for the notion pioneered by Williamson (1971) that specificity of assets to be acquired is an important factor in the decision to vertically integrate. When firms need to invest in assets that are specialized, and when the market exchange of these assets is costly, VI may align the incentives of the parties involved and may lead to efficient investment. Clearly, this is the case for airlines as a new commercial airplane costs from $100 to $150 million. Other studies focus on incomplete contracts and the incentives they create. If contracts are hard to specify, enforce, and monitor on the outside, and it is cheaper to monitor and contract within the firm, VI can increase efficiency (Kedia et al. (2011) and Lafontaine and Slade (2007)).

Drawing from the above literature, many studies have shown the impact of uncertainty on the motive to engage in VI. Uncertainty increases the difficulties associated with writing complete contracts. Without uncertainty, a perfect contract can be written to safeguard the transaction; hence, there is no need for VI (Carlton (1979), Fan and Goyal (2006), and Fan (2000)). Helfat and Teece (1987) study how VI can reduce uncertainty. They explain that there are two types of uncertainties: state contingent, like uncertainty in prices, and uncertainty resulting from lack of information. The latter may diminish with VI. Carlton (1979) suggests that producing inputs internally (vertically integrating) can help a firm facing price uncertainty by allowing it to produce cheaply. He shows that firms are likely to integrate backward when they encounter substantial variability in the input market and the input market is uncorrelated with fluctuation in their own downstream market. Though general economic conditions affect both oil production and customer demand for air travel, an airline's upstream and downstream markets are far from perfectly correlated. For example, the sharp oil price declines over the latter half of 2014 appear entirely unrelated from factors affecting demand for travel.

Fan (2000) studies VI among petrochemical firms and links it with input cost uncertainty through detailed industry-specific analysis. He finds strong evidence from the 1970s that input price uncertainty and asset specificity jointly affect VI in the industry. Oil shocks in the 1970's caused contracting problems in the petrochemical industry; several organizations responded by vertically integrating. Indeed, input cost uncertainty was arguably the chief driver of the Trainer deal. With mounting U.S. East Coast refinery closures threatening to cripple Delta's ability to procure reasonably priced jet fuel, the growing pains of learning how to operate the refinery seemed more than bearable compared to the costs associated with a probable fuel shortage.

Fan and Goyal (2006) find that, on average, vertical mergers are associated with significant positive wealth effects. The average wealth effect during the three-day window around the announcement is 2.5%. On the other hand, Kedia et al. (2011) find no effect on the value generated from VI in the face of market uncertainty. Therefore, there is cause to adopt an initially agnostic view of the acquisition's wealth implications on Delta.

Recently, Garfinkel and Hankins (2011) find that risk management is indeed one of the motives behind VI. They show that it reduces cash flow volatility and yields a drop in the cost of goods sold after integration. They also find changes in slack cash (used to protect against the effect of variability in internal funding) is negatively related to VI, consistent with VI providing an additional hedge.

Several studies also examine the interaction between financial hedging and VI. Haushalter (2000) asserts that it is a substitute for financial hedging. Hankins (2011) corroborates this result, empirically, by showing that large increases in operational hedging (e.g., acquisitions) are followed by large declines in financial hedging among bank holding companies. Turning to Delta's refinery purchase, we expect the acquisition to have a stabilizing effect on the airline's fuel costs net of refining profits. If jet fuel prices increase, higher airline operating costs will be partially offset by higher refinery profits. This is true because refining margins tend to move with crude oil prices as Figure 1 shows. Through this mechanism, we expect the refinery to reduce Delta's cash flow volatility. To the extent that investors value reduced cash flow volatility, hedging, in this case through the refinery acquisition, can potentially increase firm value (Froot et al. (1993)). This notion is also consistent with Garfinkel and Hankins (2011) finding that reduced cash flow volatility is a motive for VI.

3. The Context Leading to Delta's Acquisition of Trainer Refinery

The U.S. airline industry was deregulated in 1978. Since then it has suffered from consistent losses (Carter et al. (2006)), which has puzzled industrial organization economists. As shown by Borenstein (2011), this dismal financial record is not what economists predicted in 1978 and it is a challenge to the views of deregulation advocates. The same author shows that there is no conventional long-run equilibrium explanation for an industry that perpetually loses money and he offers some explanations based on taxes, cost shocks, demand shocks, or a series of unfavorable events.

On top of this dismal history, there has been an upward trend in the cost of jet fuel. Fuel price increases over the past decade coincided with reduced profits and, in many cases, operating losses among carriers. As shown in , airfares trended upward but at a much slower pace than oil price increases due to intense competition. These trends put great pressure on the airline industry. From 1995 to 2003, fuel cost an average of $0.66 per gallon. In 2012-2014, one gallon of jet fuel cost around $3 per gallon. The rise in the cost of fuel between 2000 and 2012 resulted in fuel becoming one of aviation's largest operating expenses. From 1995 to 2003 fuel represented about 15% of the operating costs; during 2012-2014, fuel was 30% of operating cost. This has incentivized airlines to save on the fuel cost bill wherever possible. As a result, airline productivity–most commonly measured as the number of available seat miles (ASMs) per gallon of fuel consumed (ASM/g)–rose 14.5% from 2000 to 2010, from 55.4 to 64.8 ASM/g (Firestine and Guarino, 2012). Figure 1 describes the evolution of crude oil and jet fuel prices from April 1990 to August 2015.

****** Insert Table 1 and Figure 1 about here ******

In this context, Delta Air Lines surprised the market with its move to acquire Trainer refinery as a way to curtail the cost and ensure the supply of jet fuel. A timeline of the events leading up to Delta's purchase of the Trainer refinery, and of developments subsequent to this purchase, is presented in Table 2. The deal bought Delta a refinery with an 180,000 barrel per day capacity and pipelines and terminal assets that allow the refinery to supply jet fuel throughout the Northeastern United States, especially to LaGuardia and JFK airports. Trainer itself represents 13% of the US East Coast jet fuel supply. Trainer was idled and put up for sale in September 2011, among other refineries representing 50% of East Coast capacity. According to an EIA report in 2012 (U.S. Department of Energy, 2012), most of these closures were attributed to the inability to process heavy sour crude, which trades much lower in price than the benchmark Brent. Delta Air Lines acquired Trainer through its subsidiary, Monroe Energy LLC, which operates the refinery with its own management team and board of managers.

****** Insert Table 2 about here ******

shows how much jet fuel Trainer provides to Delta from production and from swap agreements. In the announcement disclosing the intended acquisition, Delta mentioned that it expected to save $300 million annually in fuel expenses by sourcing jet fuel from Trainer. An important component of the Delta move was the ability to swap non-jet fuel refinery outputs, like diesel and gasoline, for jet fuel sourced from elsewhere in the United States. Delta entered into two swap agreements: one with Phillips 66 and the other with British Petroleum (BP), described in Figure 3. The agreement with Phillips 66 required Delta to deliver specified quantities of non-jet fuel products in exchange for specified amounts of jet fuel. If Delta or Phillips 66 did not have the specified quantities, the delivering party was required to procure any shortage from the market. The remaining production of non-jet fuel products was to be sold to BP under a long-term buy/sell agreement to exchange non-jet fuel products for jet fuel.

****** Insert Figures 2 and 3 about here ******

In July 2014, the BP swap agreement was terminated early and BP was replaced with another, unnamed, counterparty. Shortly thereafter, Monroe announced that Bridger LLC, a privately held midstream company, would supply 65,000 bpd of North Dakota Bakken crude to its refinery, helping it reduce its reliance on costlier imports.

Delta reports the gain/loss from its financial hedging program as well as the gain/loss from its refinery segment on its quarterly SEC filings. Considering the Delta acquisition as an operational hedge, this provides an explicit measure of the gains/losses from both financial and operational hedging, unlike existing studies of operational hedging (see Fan (2000) and Hankins (2011)). 4 shows the gains/losses from hedging and from refinery operations and shows cumulative profitability measures since Q42012. First, it is clear that hedging program contributed losses over that time frame and is highly volatile while refinery operations have a cumulative gain and are less volatile. The correlation between the two “hedging” programs is almost nil.

****** Insert Figure 4 and Table 3 about here ******

To understand the full impact Trainer may have on Delta’s exposure to input costs, we must also consider traditional hedging instruments (financial hedges) that Delta employs, since incorporating the refinery’s output has likely affected the company’s use of other financial instruments. Airlines typically hedge their exposure to fuel costs with crude oil and heating oil derivatives because the derivatives market for jet fuel is miniscule and very illiquid.[1] Airlines employ futures, options, forward purchase agreements, collars and swaps, among other strategies, to reduce exposure to fuel price fluctuations. Towards that end, we hand-collect hedging data from quarterly SEC filings for Delta and other publicly traded U.S. airlines. Our primary measure of hedging intensity is the hedge ratio for the following quarter. This measure estimates the amount of next quarter's fuel consumption hedged by derivative contracts. Appendix 1 details the hedge ratio computations.

In spite of the findings of Haushalter (2000) and Hankins (2011), who assert that financial hedging and vertical integration are substitutes, Delta initially increased both the extent and the duration of hedging after the acquisition. Delta has also continued its financial hedging through derivatives. Figure 4 summarizes quarterly reports of the notional balance of barrels that underlie Delta's derivatives contracts along with the latest maturity of these contracts. Delta appears to have ramped up hedging toward the end of 2013 and reduced it by 2015. Delta does not disclose the breakdown of commodity types underlying these contracts. However, reason suggests that, post-acquisition, Delta would purchase more crude oil and less jet fuel than it did pre-acquisition. This dramatic ramp up in the extent of hedging is abnormal relative to its competitors, as shown by Table 4; financial hedging cost Delta a huge loss, around $2 billion, in the last quarter of 2014 due to the plunge in the oil prices. Figure 5 presents Delta's quarterly gain/loss from hedging and refinery operations, and also shows the notional balance in barrels Delta contracted for and the latest maturity of these contracts at each quarter's end.

****** Insert Figure 5 and Table 4 about here ******

Table 4 shows hedge ratios for Delta and other airlines from 2009 through 2015. This table documents dramatic heterogeneity in hedging policies among airlines. For example, Hawaiian Airlines has a set policy of hedging 50 percent of its next quarter's anticipated fuel consumption. US Airways, in contrast, stopped hedging altogether in 2009 and has not hedged since. Southwest, on the other hand, seems to have hedges in place for some quarters and no hedges for others. In sum, our estimated hedge ratios fluctuate dramatically from 0 to 100 percent and typically range between 20 and 50 percent of next quarter's anticipated fuel consumption. We observe no abnormal hedging behavior for Delta around the time of the refinery acquisition, though it appears to have ramped up hedging toward the end of 2013 and reduced it by 2015.

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[1] For hedging instruments and strategies airlines use, Carter, et al. (2006).

4. Why Delta?

External and internal factors could explain why Delta, and not another airline, acquired a refinery. The internal factor is an innovative management culture. The Trainer refinery acquisition was not Delta's only innovative move, as noted by its CEO (Anderson (2014)):

> *"We started, just after our two-year restructuring, with an employee profit-sharing program that continues to differentiate us from our peers. Each year, 10% of earnings before taxes and management compensation is paid out in bonuses. A year after our 2008 merger with Northwest Airlines, we added a stock ownership plan also unique in the industry that gave our pilots, flight attendants, ground crew members, and support staff 15% of the company's equity. We have reclaimed our reservations system, becoming the only U.S. airline to own and control this key operations data. We have deepened our foreign partnerships by buying a minority stake in three overseas carriers--Aeromxico, Brazil's GOL, and the UK's Virgin Atlantic--and strengthened our existing alliance with Air France-KLM. We have also moved toward vertical integration (and better management of fuel costs) by acquiring an oil refinery, a decision that shocked both aviation and oil industry observers."*

The external factor is related to the specificity of Trainer to Delta. According to the VI literature, asset specificity is a major factor why companies vertically integrate, especially to confront uncertainty. Indeed, Delta considers the New York market as an important part of its network strategy; in 2012, Delta had the largest market share in New York market for domestic flights. According to Bureau of Transportation Statistics (BTS), Delta's share of passengers in New York market is 22.76%, while JetBlue and American come next with 21.9% and 16%, respectively. Trainer is a very important source of jet fuel for New York-based flights. Moreover, the acquisition includes pipelines and terminal assets, allowing Trainer to supply jet fuel to the New York hubs at LaGuardia and JFK. The Trainer refinery's output represents 13% of the East Coast's total refining capacity. Delta stated that strengthening its position in New York City is an important part of its strategy. In its 2012 report, Delta states that "key components" of its strategy are operating a domestic hub at LaGuardia and international hub at JFK. Delta considers LaGuardia to be a new domestic hub, and has increased capacity at LaGuardia by 42% since March 2012, adding 100 new flights and a total of 26 new destinations. At the end of 2012, Delta operated about 260 daily flights between LaGuardia and 60 cities – more than any other airline. Also, in 2012 Delta invested more than $160 million in a renovation and expansion project at LaGuardia to enhance the customer experience. In 2010, Delta started a five-year $1.2 billion renovation project at JFK to turn it into an international hub in the New York City area (Delta's 2012 Financial Report).

5. Empirical Analysis of Delta's Acquisition of Trainer Refinery

In this section, we explore the costs and benefits of the refinery acquisition. We first show, using event study methodologies, that investors in equity and debt markets reacted favorably to the announcement of the acquisition. Then, we empirically investigate the channels through which the acquisition may have benefited Delta.

To separate the causal impact of the refinery to potentially coincidental operating environments we attempt to contrast Delta with its peers throughout our empirical analysis. Thus, we must first determine the appropriate peers to use within the U.S. airline industry. According to the United States Department of Transportation, there are more than 50 passenger airlines, most of which are small regional carriers. Given that Delta is a major public passenger airline, we restrict our sample to large public carriers designated as a "major carrier" by the U..S. Department of Transportation as of the end of 2012 (the first quarter after the acquisition). The following airlines meet these criteria: Frontier, AirTran, Alaska, Allegiant, American, Frontier, Hawaiian, JetBlue, SkyWest, Southwest, Spirit, United and US Airways. We restrict our analysis to the sample from 2009 through the second quarter of 2016. Beginning in 2009 allows enough time to gauge airlines' performance before the acquisition, yet avoids the worst of the recent financial crisis. summarizes these airlines' capacity in term of available seat miles, market share at the end of 2012, and their market state (private or public and merger events) during the sample period.

****** Insert Table 5 about here ******

5.1. Event studies

In this section, we study the reaction of equity and bond market to the acquisition announcement. We begin with a stock market event study to assess the acquisition's anticipated impact on Delta's shareholders. We cross-validate these results through a relatively new econometric technique, the synthetic control method (Abadie and Gardeazabal, 2003) which constructs a hypothetical Delta Air Lines using a linear combination of its competitors attributes. Examining the difference between Delta's stock price and the predicted stock price of synthetic Delta presents another estimate of the acquisition's value. Next, we conduct a bond market event study to gauge the acquisition's effect on Deltas creditors. We validate bond market results by examining another proxy for Deltas credit risk, its CDS spread.

5.1.1. Equity market

We test whether the refinery acquisition affects investor welfare through the event study framework described in Campbell et al. (1997). Our event date, April 30, 2012, is the day Delta publicly announced it would acquire the refinery. If investors favored the deal, Delta's stock price should exhibit significantly positive abnormal returns around the announcement date. Insignificant returns are consistent with investor indifference toward the refinery, while negative returns would suggest anticipated value destruction from the refinery acquisition. Importantly, though acquisition rumors circulated prior to the official announcement, any information impounded prior to that date would bias our findings away from statistical significance.

We estimate the following model:

$$R_{Delta,t} = \alpha + \beta_{Mkt} * R_{Mkt,t} + e_t$$

where $R_{Delta,t}$ denotes Deltas stock return on day t, $R_{Mkt,t}$ denotes day t return on the S&P 500 index (a proxy for the market portfolio), and e_t is the residual term. Abnormal returns are defined as the difference between the actual and the fitted returns. We cumulate abnormal returns over the event window to gauge how stockholders expect the acquisition to impact value. We use the Patell Z test to determine whether the cumulative abnormal return, CAR, around the announcement is statistically significant.

Table 6 presents the results of our stock market event study. Panel A documents that Delta experienced a positive CAR of 5.71% over the three-day period centered on the announcement date, that is CAR (−1, +1). Though this value is only significant at the 10 percent level, the figure is highly meaningful considering the sample size of one firm in this event study. Panel B disaggregates this CAR to show that most of the abnormal return took place the day before the announcement. This suggests some degree of anticipation or news leakage in the market. While we favor the market model's simplicity as an estimation model, untabulated analysis confirms identical results using the Fama and French 3 Factor model or the Fama and French 3 Factor model augmented with an airline industry factor. Overall, these results suggest that Delta increased shareholder wealth through the acquisition. Given Delta's $8.79 billion market capitalization two trading days prior to the announcement, a three-day CAR (−1, +1) of 5.71% translates to $501.9 million in additional wealth generated.

****** Insert Table 6 about here ******

To test these results' robustness, we employ the synthetic control method (SCM) pioneered by Abadie and Gardeazabal (2003). Acemoglu et al. (2014) use SCM as a tool to study the wealth effect of the announcement that Tim Geithner would become Treasury Secretary in November 2008 on financial firms with links to Geithner. We analogously employ SCM to study the effect of the Trainer acquisition announcement on Delta's returns. The technique attempts to synthesize Delta's stock return in the absence of the acquisition using a weighted average of its competitors' returns. The weight assigned to each competitor airline is determined to minimize squared errors between Delta's actual returns and Synthetic Delta's returns in the pre-acquisition period. That is, if $R_{Delta,t}$ is the return on Deltas stock and $R_{i,t}$ is the return on airline i of the control group, we construct a synthetic Delta stock return by solving the following program:

$$\{w_i\}_{i \in Control\ Group} = argmin \sum_{t}^{T} \left(R_{Delta,t} - \sum_{i} w_i R_{i,t} \right)^2$$

subject to $\sum \omega_i = 1$ where [t, T] is the estimation window in the pre-acquisition period and ω_i is the weight assigned to the stock return of airline i. Once ωi for each control group airline is determined, CAR_{Delta} (−k, +k) where k is number of days around the announcement is calculated as:

$$CAR(-1,+1)_{delta,SC} = \sum_{-1}^{+1} \left(R_{Delta,t} - \sum_{i} w_i R_{i,t} \right)$$

We repeat the same analysis replacing Delta with each other airline in the control group and calculate its CAR_i (−k, +k) over the same window. These CAR_i (−k, +k) help construct a distribution of cumulative returns not caused by the treatment against which the significance of CAR_{Delta} (−k, +k) is tested. The pool of control units consists of public airlines, among those in table 6, that were actively trading at the time of the announcement. Namely, the pool consists of Allegiant, United, SkyWest, Southwest, JetBlue, Hawaiian, Alaska, Spirit and U.S. Airways. The announcement was in April 30, 2012, so we use observations from January 1, 2011 to 50 days before the announcement in the estimation window. We choose 50 days to avoid the possible effect of any leak before the announcement. Stock market return data come from CRSP. If the acquisition announcement positively (negatively) affects shareholders, then Delta's CAR (−1, +1) should be significantly higher (lower) than that of other airlines.

shows the result of SCM analysis. The results show that in synthetic Delta, UAL, JBLU and LCC are given large weights (0.335, 0.23 and 0.201). This is expected as LCC and UAL, like Delta, are network and legacy and JBLU shares with Delta that around 45% of New York market passengers, as shown in the last section. This lends credibility to the SCM estimates. These SCM results for CAR also support the idea that the market reacts very positively, relative to industry peers, to Delta's refinery purchase announcement. Deltas stock price experiences a 5.1% CAR (−1, +1), a number that is significantly higher than the other firms experienced over the announcement period, indicating that the effect is unique to Delta around the announcement date. Ideally, one would employ bootstrapping techniques to construct a distribution of cumulative abnormal returns of the control group against which the treatment cumulative abnormal return could be tested. Industrial limitations constrain our control group to only seven units which renders bootstrapping impractical. However, Delta's CAR is beyond 2.3 standard deviations from the center of the control group. This sizable distance suggests that the effect for Delta is significantly different from that of the control group. Thus, from the above results, it is clear that stock market reacted favorably to news of the refinery's purchase.

****** Insert Table 7 about here ******

5.1.2. Bond market

Next, we investigate how the market for Delta's bonds reacted to the acquisition announcement. Bondholders, too, may value the acquisition as a means of reducing exposure to fuel price risk. However, they may also believe that diversifying into an industry outside of management's expertise will be risky and increase the likelihood of default. In fact, Moody's credit rating agency issued the following statement two days after the announcement:

> "*The decision by Delta Air Lines to purchase the Trainer refinery complex is negative for Delta's credit profile. We believe potentially significant operating and financial risks accompany owning and operating an oil refinery, which could lead to shortfalls between actual financial benefits and those of the project's business case.*"

If bondholders side with the rating agency, we expect significantly negative returns around the announcement date. Conversely, if the anticipated fuel price risk-reduction effect prevails, we expect positive bond market returns.

Bessembinder et al. (2009) and Ederington et al. (2015) identify several complications to bond market event studies, such as infrequent trading and significant heteroskedasticity between bonds and firms. These issues render classic event study techniques problematic. Fortunately, the authors provide insightful recommendations on how to best conduct a bond market event study; we adhere to their suggestions as closely as possible. Specifically, we (1) generate returns using daily rather than monthly bond price data; (2) compute daily bond prices as the volume-weighted average of all trades for a given bond on a given day; (3) extend our event window to the (-5,+5) period; (4) calculate expected bond returns using a bond-level control groups matched on maturity and credit rating (we alternatively employ a control group of airlines bonds); (5) account for heteroskedasticity across bonds and firms by standardizing each return; and (6) employ non-parametric tests for statistical inference. From the TRACE database, we obtain all bond trades six months before and after April 30, 2012. We merge this set with the Mergent RISD Bond Rating database to obtain each bond's ratings; bonds with missing CUSIPs or ratings are dropped. Per Bessembinder et al. (2009) and Ederington et al. (2015), we also eliminate canceled, corrected, and commission trades, trades with settlement dates over one week in the future, when issued or special trades, trades with sales conditions, and irregular trades--indicated by TRACEs as flag, zero-coupon bonds, and bonds in default.

To compute returns, we require that a bond trades at least once in the five days prior to the announcement date and at least once in the five subsequent days. When a bond trades multiple times in one day, we weight each trade by the square root of trade volume to obtain a daily bond price. We calculate returns for up to eight periods over the t-5 to t+5 window where t=0 represents the announcement date. For example, if a bond trades on days t-3, t+1, and t+5, we generate two returns: the 5-day return from t-3 to t+1 and the 9-day return from t-3 to t+5. Returns are then standardized by that bond's 5- and 9-day return standard deviations calculated from trades occurring six months before the 11-day event window and six months after. For each day, d, from 3 to 11, if the bond does not generate at least six d-day returns in the twelve months around the event window, its returns are excluded to avoid unrepresentative standard deviations. Returns are trimmed at the 1 and 99% levels to avoid the impact of extreme outliers. Finally, standardized d-day returns for each of Delta's bonds that trade in the event window are compared to standardized d-day returns for a maturity and rating matched sample of all bonds, airline standardized d-day bond returns, and maturity and rating matched airline d-day bond returns. These differences are tested for statistical significance using the Student's t and signed rank tests.

The results of our bond market event study are reported in Table 8. Panel A describes mean and median returns for Delta and three potential benchmarks. Mean and median returns for Delta range around two times mean and median benchmark returns, regardless of the benchmark. When accounting for heteroscedasticity between bonds, the contrast is even more stark. Delta's returns exceed zero by 3 to 5 times as many standard deviations as benchmark returns do. Panels B and C show that these differences are highly statistically significant regardless of the choice between raw or standardized returns and between parametric or nonparametric tests. Overall, it is clear that bond market participants positively valued the acquisition, despite Moody's bearish forecast.

****** Insert Table 8 about here ******

Figure 6 presents levels (upper chart) and changes (lower chart) in CDS spreads, respectively. Visual analysis of this figure indicates that Delta's perceived default risk falls dramatically while those of United, Southwest, and JetBlue remain constant around the time of the acquisition.

****** Insert Figure 6 about here ******

6. Has Delta's Strategy Been Successful?

After verifying that all event study results point in the same direction – shareholders, creditors, and CDS investors expect the acquisition to generate value – we explore whether or not Trainer's acquisition and integration has been a beneficial hedge for Delta. The corporate risk management literature predicts that reducing cash flow variability through risk management can add value by reducing the likelihood of costly financial distress (Smith and Stulz (1985)); reducing the need for costly external financing (Froot et al. (1993)); reducing underinvestment and asset substitution, and benefiting from convexity in the cost structure (refer to Aretz and Bartram (2010) for an extensive review of these theories and the empirical support each receives).

We first check whether Trainer reduces fuel risk for Delta relative to its peers. Next, we assess whether the equity market credits Delta with the risk reduction. Finally, we test whether bond markets also perceive reduced risk for Delta, post-Trainer. Campello et al. (2011) predict that a company with better risk management will have less costly access to external financing. To check this, we measure how the how Delta's external financing cost has changed relative that of its competitors around the acquisition. Overall, the risk reduction channel helps us formulate the following hypotheses:

Hypothesis 1. Delta's fuel costs become less variable, relative to its peers, after the acquisition.

Hypothesis 2: Delta's share price becomes less sensitive to crack spreads, relative to its peers, after the acquisition.

Hypothesis 3. Delta's access to external financing becomes significantly cheaper, relative to its peers, after the acquisition.

6.1. Fuel price variability reduction

One channel through which Trainer could add value is through risk reduction. Theories of hedging and VI assert that such a move could add value if it reduces the company's cash flow variability. We first check if Trainer has a potential to reduce the variability of cash flow coming from the fuel cost which constitutes around 25% of Delta's operational costs. To analyze this question, consider a simple model where Q_T is the total gallons of jet consumed by Delta and P_J, P_C and P_O are the prices of jet fuel, crack spread, and crude oil (note that by definition ($P_J = P_C + P_O$), respectively, then:

$$Q_T \cdot P_J = Q_T \cdot P_C + Q_T \cdot P_{oil} = Q_r \cdot k + Q_m \cdot P_C + Q_T \cdot P_{oil}$$

where Q_r is the amount of jet sourced from the refinery and Q_m is the amount of jet sourced from the market. Assuming the k is constant or at least predictable, then it can be shown that if α_m is Q_r/Q_T, then:

$$Var(\Delta P_J) = \alpha_m^2 Var(\Delta P_c) + Var(\Delta P_o) + 2\alpha_m Cov(\Delta P_c, \Delta P_o)$$

which can be written as:

$$\sigma_J^2 = \alpha_m^2 \sigma_c^2 + \sigma_o^2 + 2\alpha_m \sigma_c \sigma_o \rho_{c,o}$$

For Delta, α_m is around 0.6 while it is 1 for other airlines. Thus, the variability of Delta fuel cost is function of $\rho_{c,o}$. If the correlation is positive, then there is always a potential for variability reduction. If $\rho_{c,o}$ is negative, then it depends on the size of α_m and the size of correlation. We plot the rolling version of equation 6 using a weekly data of jet fuel, crack spread, and crude oil prices. We use a window of 50 weeks as the rolling window. Figure 7 shows the rolling standard deviation using equation 6 when $\alpha_m = 0.6$ (which corresponds to Delta) and when $\alpha_m = 1$ (which correspond to other airlines). In almost all realized scenarios of the comovement between oil and crack, sourcing part of jet fuel from a refinery has a potential to reduce the variability of per barrel cost of jet fuel.

To get a sense of size, note that Delta consumes around 3,867 million gallons of jet fuel per year on average since 2012. Thus, the reduction in fuel cost variability amounts to around 256 million dollar per year relative to sourcing all jet from the market. Of course, this calculation assumes k, the per- unit cost of refining, to be constant. However, this may not be the case. For example, operational disruption is a key source of risk to refineries. In 2012 report, Delta says: "During the December 2012 quarter, fuel production increased at the refinery. However, superstorm Sandy negatively impacted the refinery start- up, slowing production and lowering efficiency levels. The refinery recorded a $63 million net loss for the quarter". Nevertheless, variability of the per-unit cost of refining is expected to be less than the variability of the jet fuel crack spread.

****** Insert Figure 7 about here ******

Has the refinery reduced Delta's variability? Table 9 shows that the variability of per-gallon cost, measured by the standard deviation of the change in per-gallon fuel cost, increased in the post- Trainer period. However, closer inspection reveals that this increase is due to the huge loss in Delta's hedging program in the first quarter of 2015. Once this outlier is removed from the sample, Delta's variability appears to decrease in the post-Trainer period. However, this cannot be considered definite evidence that Trainer reduces Delta's fuel cost variability as this may be due to hedging not due to the refinery operation.

****** Insert Table 9 about here ******

6.2. Perceived risk reduction in equity markets

If Trainer is perceived by investors as a valuable hedging tool, then one may expect that equity price exposure to the crack spread for Delta is significantly less than other airlines in the post Trainer period. To test this hypothesis, we estimate the following OLS model

$$R_{i,t} = \alpha + \beta_m R_{m,t} + \beta_c R_{c,t} + \beta_o R_{o,t} + \beta_p post_t + \beta_{po} post_t \times R_{c,t} + \beta_{po} post_t \times \beta_o R_{o,t} + \beta_{ch} HR_i \times R_{c,t} + \beta_{oh} HR_i \times R_{o,t} + \epsilon_{i,t}$$

where $R_{i,t}$ is the log return on the share price of airline i at time t; $post_t$ is a dummy for the post-Trainer period; $R_{m,t}$ is the log return on the S&P 500, used as a proxy for the market portfolio; $R_{c,t}$ is the log return on the crack spread, measured by the difference between jet fuel and crude oil prices; $R_{o,t}$ is the log return on the price of WTI or Brent oil benchmark; and H $R_{i,t}$ is the hedging ratio of airline i which is equal to the ratio of next year's consumption that is hedged. A hedge ratio at time t corresponds to the ratio that is reported in the last published statement. We use of weekly data from 6/05/2009 to 3/25/2016. Price data are obtained from CRSP and hedge ratios are obtained from the companies' quarterly filings. Appendix 1 details hedge ratio calculation. γ_C is the parameter of interest. It is expected to be negative and significant if the market perceives that Trainer reduces Delta's exposure to the crack spread. We run this regression, separately, for Delta as well as its peers.

Table 10 shows the regression estimates of the above model for Delta. The first two columns estimate equation 7 using WTI and Brent oil benchmarks respectively to calculate $R_{o,t}$ as well as $R_{c,t}$ but without including the hedge ratios. We can see from the first column that the exposure to oil is significantly negative and it is much higher than that to crack spread. This is expected considering the fact that crude oil constitutes a much larger fraction of the jet fuel price. In the post-Trainer period, oil exposure decreases. This is expected given the drop in oil price in the mid 2014; airlines are expected to be less sensitive to oil price when they are low.

The parameter of interest, γ_C shows the expected sign but is not significant. All above observations obtain using the Brent benchmark as shown in the second column. In the third column, we estimate the full version of equation 7 including hedging ratios. We observe that γ_C shows the expected sign and is significant. That is, when considering hedging activity Delta's exposure to crack spreads reduces in the post-Trainer period. The results also show that hedging reduces exposure to oil prices which is expected and in line with literature (e.g. Carter et al. (2006) and Jin and Jorion (2006)).

****** Insert Table 10 about here ******

shows the estimation of equation results for other airlines. Most airlines have negative and significant exposure to oil and insignificant exposure to crack spreads. Unlike Delta, no airline shows a significant change in its exposure to crack spreads in the post-Trainer period. Interestingly, US Airways (LCC), United (UAL) and JetBlue (JBLU) share with Delta their increased exposure to crude oil in the post-Trainer period suggesting that this observation may not be due to something specific to Delta. Overall, these two tables show evidence that Delta's equity exposure to the crack spread has been reduced in the post Trainer period.

****** Insert Table 11 about here ******

6.3. Perceived risk reduction in bond and loan markets

To assess whether the acquisition reduces Delta's credit risk, we use a difference in differences estimation technique. We measure how the difference between Deltas bond yields and those of its competitors changes around the acquisition. Through this framework, we can better control for credit spread changes resulting from macroeconomic factors such as crude oil price swings or fluctuating air travel demand. Our sample period is 2009 through 2015 which constitutes fifteen quarters before the acquisition, two quarters associated with the acquisition announcement and implementation, and fifteen quarters after the acquisition. Our sample includes bond yields from Delta, U.S. Airways, American (after its merger with U.S. Airways to exit bankruptcy), United, Southwest, Hawaiian, and JetBlue. We require stock market data to compute a firm's market to book ratio (one of our controls). For this sample, we estimate the following OLS model:

$$Spread_{i,t} = \alpha + \beta_D * Delta + \beta_P * Post + \beta_{DP} * Delta * Post$$
$$+\gamma_{TC} * Trade\ Characteristics_{i,t}$$
$$+\gamma_{FC} * Firm\ Characteristics_{i,t}$$
$$+\gamma_{BC} * Bond\ Characteristics_{i,t} + e_{i,t}$$

where Spread is the difference between the bond i's yield to maturity on trading day t and the benchmark treasury yield. If a bond trades multiple times in one day, its yield is the sum of individual trade yields weighted by the square root of their trade volumes. Benchmark treasury yield is computed as a linear combination of yields for the two reported U.S. treasury securities that mature around the bond's maturity date (the closest-maturity treasury before the airline bond's maturity, and the closest after). For example, consider a trade of an airline bond with 8 years remaining until maturity. Because the U.S. treasury does not report an 8 year treasury yield, benchmark treasury yield would be calculated as 2/3 of the reported 7 year treasury yield that day plus 1/3 of the 10 year treasury yield.

In all specifications, β_{DP} is the coefficient of interest. A negative sign indicates that Delta's bond yield significantly declines in the post-acquisition period after controlling for trends in other airlines' bond yields. It is important to control for other important determinants of bond yields, as it has been well documented that smaller trades suffer from a larger bid-ask bounce and trades closer to maturity reflect less repayment uncertainty (Ederington et al. (2015)). We, therefore, include trade size and time remaining to maturity as trade-level controls. We control for firm size, leverage, and growth opportunities using the natural logarithm of total assets, the ratio of book debt to book assets, and the sum of market equity and book liabilities scaled by book assets. We account for periods of rapid crude oil price increases (January 2009 through April 2011) and decreases (June 2014 through January 2016) with two indicator variables whose values equal one if the trade takes place within that period, and zero otherwise. For robustness, we employ year fixed effects in another specification.

Bond-level idiosyncrasies such as level of seniority, collateral, and embedded options also significantly affect yields. We therefore include controls for call, put, and convertibility options, bond seniority, credit enhancements, restrictive covenants, the presence of collateral, and bond type (corporate debenture, corporate convertible, asset-backed security, with corporate pass through as the omitted category). An alternative specification employs bond fixed effects. Finally, we include a variable to represent bond rating categories. If the bond is rated in the top two categories (AAA/AA), this variable assumes the value of 1, if it is rated A, then 2, BBB then 3, and so on. Because our data contain many observations of the same bond, we cluster standard errors at the bond level.

Our bond trade data contain many extreme outliers. Second, third and fourth sample moments for daily bond yields are 13391.48, 79.72 and 7530.28, respectively. Truncating at the 99th percentile still retains yields as high as 98 percent. We therefore opt to truncate at the 5th and 95th percentiles leaving a smaller yet more representative sample with variance, skewness, and kurtosis of 7.82, 2.58 and 8.35, respectively. This process attenuates our coefficient estimates over six-fold, however these lower estimates appear far more economically plausible. For illustrative purposes, we report regression results truncated at the 1st and 99th percentiles in a robustness specification. From the TRACE database, we retain all bond trades with an issuer SIC code of 4512 (commercial air travel). Using the full CUSIP, we merge this set with bond attributes and ratings obtained from the Mergent RISD bond issues and ratings databases. We then join our data to the COMPUSTAT and CRSP databases for issuer accounting and market characteristics. Finally, we merge hedging data hand collected from quarterly SEC filings in the process detailed in Appendix 1.

displays results from OLS regressions of bond spreads on the difference-in-differences indicators and controls. Column (1) reports our baseline regression results. As expected, bond traders appear to credit Delta with reducing risk through the acquisition. Pre-acquisition, spreads on Delta's bonds exceed those of its competitors on average. In the post-acquisition period, competitors' yield spreads rose but by an insignificant amount. However, over the same period, Delta's yield spreads fell relative to its peers by over 1.3 percentage points on average. These results are highly statistically significant and robust to including year-fixed effects (Column (2)) and airline-fixed effects (Column (3)) and swapping individual bond attributes for bond-fixed effects (Column (4)). Results appear much stronger when truncating at the traditional 1st and 99th percentiles (Column (5)); however, as discussed above, we believe the presence of significant outliers distorts the true relationship between the acquisition and Delta's bond risk. Of note, outlying observations belong exclusively to other airlines, not Delta.

****** Insert Table 12 about here ******

When examining investment and non-investment grade bonds separately (Columns (6) and (7), respectively), we observe a very sizeable average yield reduction of 2.6 percentage points concentrated in Delta's six non-investment grade bonds while its investment grade bonds experienced a marginally insignificant, smaller yield reduction of 47 basis points. Column (8) restricts the sample to eight quarters centered on the refinery purchase announcement (2Q2012) and consummation (3Q2012). Results show that risk-reduction did not occur immediately but rather after Trainer's successful integration into Delta's operations. This is reasonable, considering Trainer's consistent, sizeable losses until 2Q2014.

Control variables generally assume the expected signs when significant. Larger firms with more growth opportunities appear to enjoy lower spreads. In most specifications, bonds with worse ratings suffer higher spreads. The one exception is Column (4) with bond-level fixed effects. Because these ratings are extremely sticky over the sample event period, the ratings variable suffers from substantial multicollinearity when bond-fixed effects are included. Its variance inflation factor exceeds 15. We attribute this apparently counterintuitive result to multicollinearity induced by employing bond-fixed effects. The options to put and convert a bond tend to lower spreads, as do restrictive covenants. Call options tend to increase spreads while credit enhancements are also associated with higher risk bonds though the relationship may not be causal. Asset backed securities usually trade at spreads below pass-throughs, while corporate debentures and convertibles trade at higher spreads. One slightly puzzling relationship is the strong inverse association between time remaining to maturity and yield spread. Each additional year remaining until maturity lowers spread by 15 to 38 basis points, depending on the specification. One explanation is that investors holding bonds which mature sooner may only want to unwind their positions if they are risky. As such, trades observed where the bond has less time remaining until maturity may be inherently riskier. Thus, endogeneity may underlie the negative coefficient.

To validate our bond yield results, we replicate the difference in difference bond regressions using loan spreads as our variable of interest instead:

$$Spread_{i,t} = \alpha + \beta_D * Delta + \beta_P * Post + \beta_{DP} * Delta * Post$$
$$+\gamma_C * Loan\ Characteristics_{i,t} + e_{i,t}$$

We obtain all new bank loans issued to airlines from 2009 to 2014 from Dealscan. Our dependent variable is the spread on the loan in excess of the relevant LIBOR rate. We include the same three difference-in-difference variables and again are interested in the coefficient for the interaction term of Delta and Post. We control for the loan amount, number of participants, maturity, presence of collateral, and whether it is a term loan or revolver. Standard errors are clustered at the firm level.

Table 13 confirms the bond spread results, using new loan spread data instead. The coefficient in front of the Delta*Post term indicates that Delta’s spreads decrease by 70 basis points relative to its competitors in the post-acquisition period. Because of this test’s extremely limited sample size, this table is offered merely as supplemental support for our claim that creditors deem Delta a safer borrower post-announcement. Again, the difference-in-difference framework offers preliminary causal evidence that the acquisition itself helped lower Delta’s cost of borrowing. Spreads are generally higher for Delta but decrease dramatically post-acquisition. Spreads increase with amount borrowed and presence of collateral, though the latter result is likely associative, not causal.

****** Insert Table 13 about here ******

Taken together, our credit market results provide evidence that Delta's access to credit markets is ultimately enhanced by the acquisition. Delta's bonds, particularly its non-investment grade bonds, experience lower spreads after Trainer's successful integration as do its loans. This is consistent with creditor assessment of lower risk, post-Trainer. Such an explanation is consistent with classical theories of hedging and vertical integration as a risk management tool and inconsistent with Moody's original prediction that the operational risk associated with owning a refinery will outweigh its benefits.

7. Conclusions

This study assesses whether Deltas purchase of the Trainer refinery in June 2012, and subsequent integration into Delta's hedging-risk management program has been successful. Delta justified its purchase as a means to ensure a steady supply of jet fuel to its northeastern U.S. hub operations, and to hedge its exposure to fuel price and crack spread changes. This acquisition was roundly derided at the time of announcement, but using event study analysis we find that stock, bond, and CDS markets reacted favorably to the refinery purchase. We also document Delta's reduced input price sensitivity after the acquisition. We begin analyzing the sources of these valuation gains by examining how Delta's cost structure, hedging practices, and security price sensitivities change post-Trainer. We evaluate these changes in isolation, and in comparison to other publicly traded airlines, both individually and as a conglomeration formed using the synthetic control method pioneered by Abadie and Gardeazabal (2003). While all airlines benefit from the decline in oil prices, beginning in the fall of 2014, only Delta experienced valuation gains that were specifically tied to relevant dates in the company's purchase and integration of Trainers output into Delta's operations. Ongoing empirical analyses will further examine the sources of these valuation gains and determine if value enhancement is a general result of backward integration between an airline and an oil refinery or due simply to the fact that Delta was able to acquire a large, functioning refinery for $150 million–roughly the price of a single wide-body jet aircraft.

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Appendix 1: Hedge ratio computation

The hedge ratio is defined as the percentage of next quarter's anticipated fuel consumption that is hedged by petroleum product derivatives.[2] Most airlines report some version of this ratio although reporting is not consistent. When an airline reports the ratio directly, we use the reported number. Some airline-quarter observations specify the hedge ratio as of quarter-end while other report as of the filing date. The discrepancy is typically one or two months and is unlikely to systematically bias our results.

Further, on quarterly filings, most airlines do not report the percentage of *next quarter's* anticipated fuel consumption hedged but, rather, the percentage of the *remaining year's* anticipated fuel consumption hedged. Likewise, on annual filings, airlines report the percentage of *next year's* anticipated fuel consumption hedged. We make a simplifying assumption that that fuel consumption is spread out evenly over the year. That is, if, on its first quarter SEC filing, an airline reports that it has hedged 44% of its anticipated fuel consumption for the remainder of the year, we assume that it has hedged exactly 44% of its anticipated fuel consumption for the second quarter, as well. While this assumption is not realistic, the measurement error (contained in the residual term) is unlikely to correlate with dependent or independent variables. As such, this measurement error introduces noise, not bias, into our model.

A final source of hedge ratio measurement error comes from the fact that Delta is the only airline which does not report hedge ratios. Instead, the airline reports total hedge volume, the maturity date of the last hedge contract, and anticipated fuel consumption, for the remainder of the year. To compute a hedge ratio for Delta, we first divide the total hedge volume by the number of quarters until the final contract's maturity date. This gives us an estimate of quarterly hedge volume. Likewise, we estimate quarterly anticipated fuel consumption by dividing the reported anticipated fuel consumption for the remainder of the year by the number of quarters remaining in the year. This number provides estimate fuel consumption for the next quarter, assuming fuel is consumed continuously over the year, at the same rate. Finally, we divide quarterly hedge volume by anticipated fuel consumption for the next quarter to obtain a quarterly hedge ratio for Delta. Because of the simplifying assumptions, this ratio exceeds 100% for three quarters. For these quarters we right censor the observation at 100% to reduce the impact of the likely overestimated quarterly hedge ratio.

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[2] Jet fuel derivatives markets are too illiquid for airlines to hedge. Thus, airlines typically hedge using crude oil and heating oil derivatives. Hedging instruments include forward contracts, swaps, collars, and options.

Figure 1. Evolution of crude oil and jet fuel prices, April 1990-August 2015

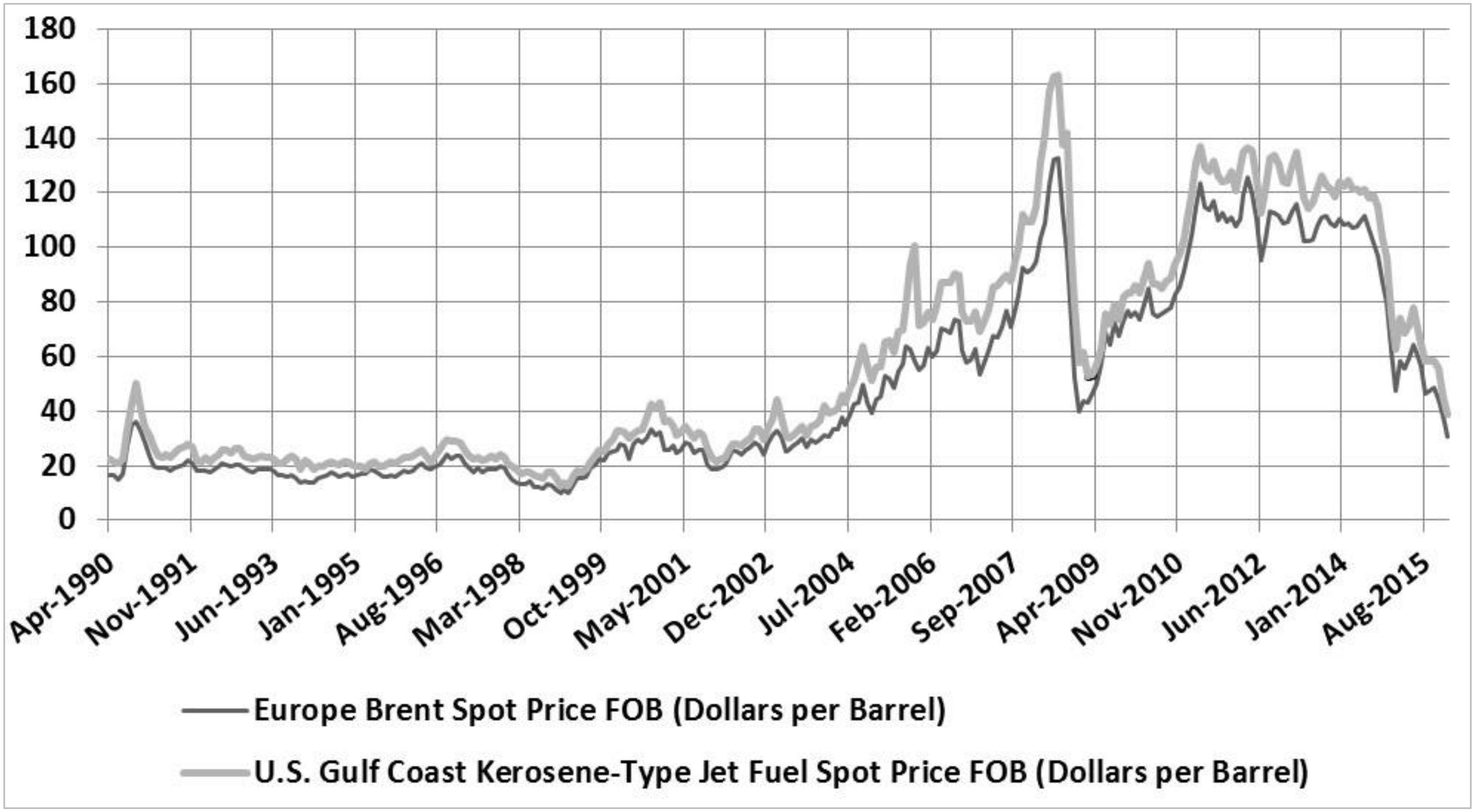


Table 1. Summary price, cost, and revenue statistics for the U.S. airline industry, 1995-2014

	1995-2003	2004-2007	2008-2011	2012-2014
Commodity Price ($)				
Crude Oil (WTI)	23.17	59.14	84.00	92.30
Crude Oil (Brent)	21.60	57.61	87.39	101.64
Jet Per Barrel	26.38	72.66	102.64	116.68
Jet Crack Spread	4.78	15.05	15.25	15.05
Average U.S. Airfare	306.47	314.55	327.00	350.99
Percentage of Fuel cost of Operating cost (%)				
American	0.12	0.23	0.27	0.29
Delta	0.12	0.21	0.28	0.29
United	0.11	0.22	0.25	0.26
US Airways	0.09	0.19	0.22	0.24
Southwest	0.15	0.24	0.32	0.33
JetBlue	NA	0.30	0.35	0.36
Alaska	0.13	0.24	0.26	0.27
Hawaiian	0.15	0.24	0.29	0.32
All Airlines	0.12	0.22	0.27	0.29
Average cost per gallon ($)				
American	0.65	1.71	2.52	2.85
Delta	0.62	1.80	2.82	3.18
United	0.69	1.75	2.43	2.91
US Airways	0.66	2.21	2.49	2.84
Southwest	0.66	1.32	2.46	3.16
JetBlue	0.37	1.69	2.58	2.91
Alaska	0.67	1.78	2.59	2.92
Hawaiian	0.71	1.84	2.52	2.87
All Airlines	0.66	1.71	2.57	2.99
	2000-2003	2004-2007	2008-2011	2012-2014
Net Income/Loss (Million $)				
American	-1422.00	-218.25	-523.25	-276.00
Delta	-608.25	-3401.75	-1559.50	4069.33
United	-2028.75	95.50	-1226.50	326.67
US Airways	-642.75	-152.75	0.00	0.00
Southwest	424.25	460.75	228.50	770.33
JetBlue	44.00	10.75	41.25	232.33
Alaska	-53.93	12.80	120.33	476.33
Hawaiian	-22.20	-13.28	63.23	58.01
All Airlines	-4633.96	-4032.70	-5120.65	6000.01

Source: U.S. Bureau e of Transportation, Bloomberg and The Airline Data Project (ADP) was established by the MIT Global Airline Industry Program.

Table 2. Timeline of major events pre- and post-Trainer acquisition

During 2011	Many shutdowns of refineries in the East Coast: • ConocoPhillips idled its Trainer refinery (185,000 barrels per day [bbl/d]) in September 2011. • Sunoco's Marcus Hook refinery (178,000 bbl/d) was idled in December 2011 • HOVENSA's U.S. Virgin Islands refinery (350,000 bbl/d) closed in February 2012. • Sunoco has announced plans to close the Sunoco Philadelphia refinery (335,000 bbl/d) in July 2012 if no buyer is found. In sum, this represents around 50% of U.S. East Coast Refineries Operating Capacity.
April 30, 2012	On April 30, 2012, Delta Airlines announced its plan to purchase Phillips 66's Trainer refinery in Pennsylvania. Monroe, Delta subsidiary, invested $180 million received a $30 million grant from the Commonwealth of Pennsylvania. The acquisition includes pipelines and terminal assets that will allow the refinery to supply jet fuel to the airline operations throughout the Northeastern U.S., including the New York hubs at LaGuardia and JFK.
June 22, 2012	Monroe Energy closes on deal.
September 2012	Trainer refinery has started production under a new management team from September 2012 onwards
March 2014	Monroe received its first shipment of Shale oil
June 2014	The multi-year product exchange agreement with a significant counterparty, BP Products North America, Inc., was terminated early effective July 1, 2014, and replaced with another unnamed counterparty.
July 2014	Monroe announced that Bridger LLC, privately held midstream company, would supply 65,000 bpd of North Dakota Bakken crude to its refinery, helping it reduce its reliance on more costly imports.
July 2014	Monroe Energy, the Delta subsidiary has time-chartered the 330,000-barrel MR Seabulk Arctic, a Jones Act vessel built in 1998, for two years beginning in August
Feb 2015	Delta reports 105 million in Trainer profits for 2014 year
July 2015	Monroe sourced oil from Nigeria. Trainer has not imported more than two million barrels of Nigerian crude in any month since June 2013. The narrowing spread has made it about $2 a barrel cheaper to import West African crude than to ship Bakken by rail from North Dakota.
February 2016	Delta report 290 million from refinery operations during 2015

Source: Delta SEC filings, media reports, EIA.

Figure 2. Trainer's supply of jet fuel to Delta, 2Q2013-4Q2015

The figure shows the amount of jet fuel Trainer supplied to Delta for its airline's operation along with the total consumption of Delta of jet fuel. Trainer jet supplies come from production of jet and swapping non-jet refined products with jet under the two swapping agreements.

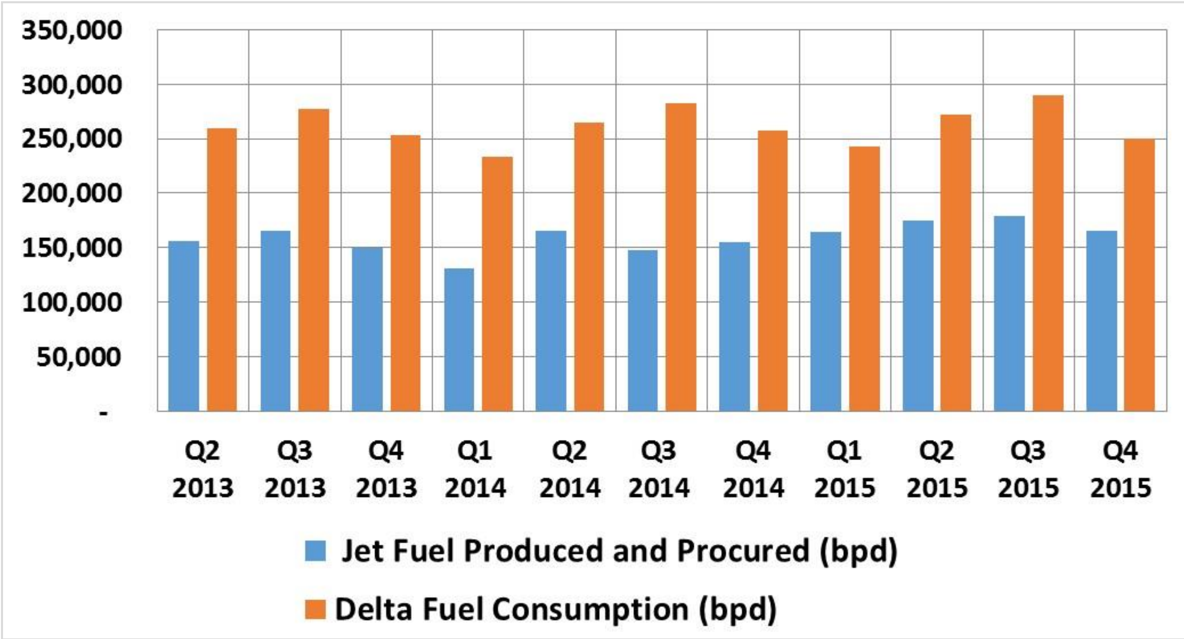


Figure 3. Swap agreements between Delta (Trainer), Phillips 66, and BP

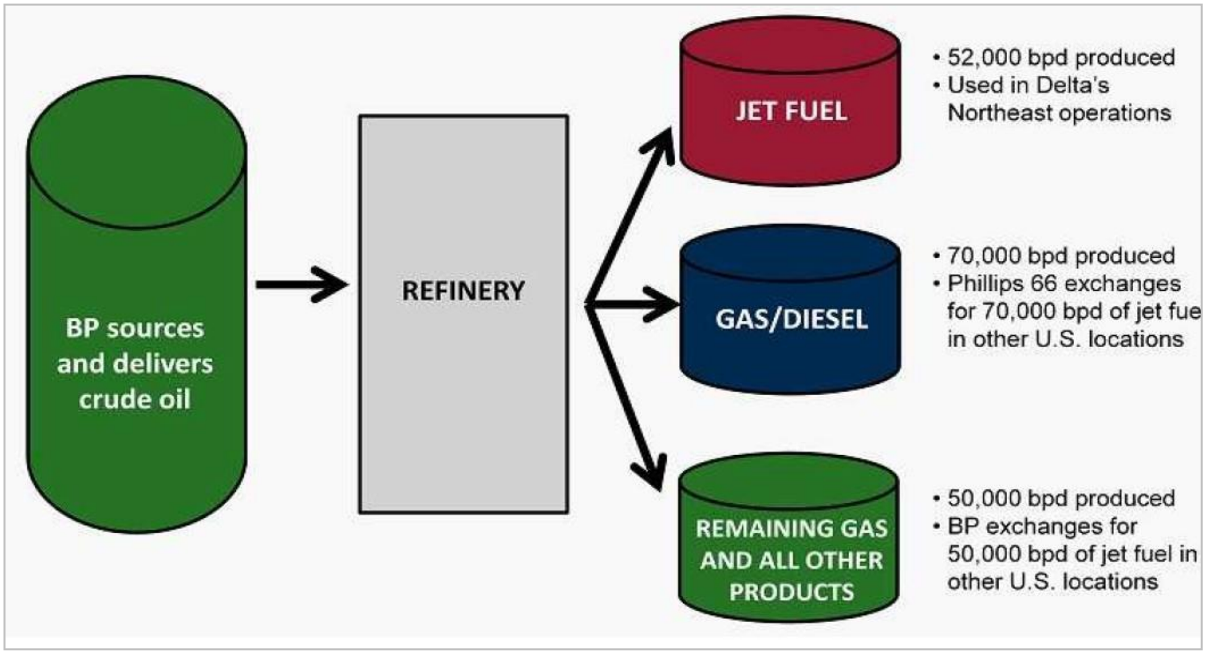


Figure 4. Delta's quarterly gain/loss from hedging and from refinery operations, 4Q2008-4Q2015

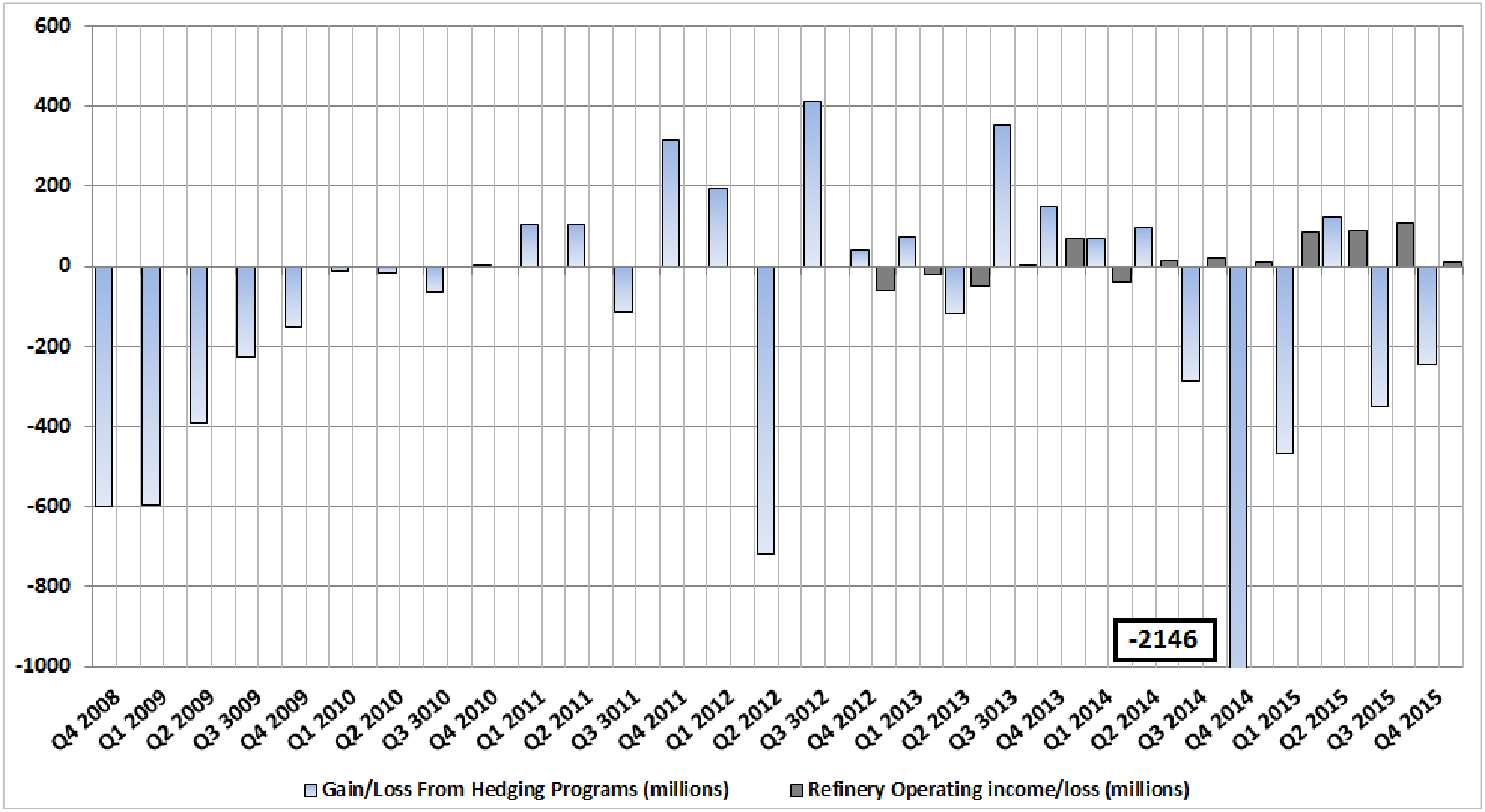


Table 3. Delta's gain/loss from hedging and from refinery operations, 4Q2012-4Q2015

The table shows the cumulative gain/loss from Delta's financial hedging program and from its refinery segment from 4Q2012 through 4Q2015.

	Gain/Loss From Hedging Programs (millions)	Refinery Operating income/loss (millions)
Sum ($)	-2,690	227
Mean ($)	-207	17
Std. ($)	478	56
Coef. of Variation	0.433	0.314

Figure 5. Hedging activities of Delta Air Lines

Shows the notional balance in barrels that underlies Delta's derivatives contracts along with the latest maturity of these contracts at the end of each quarter.

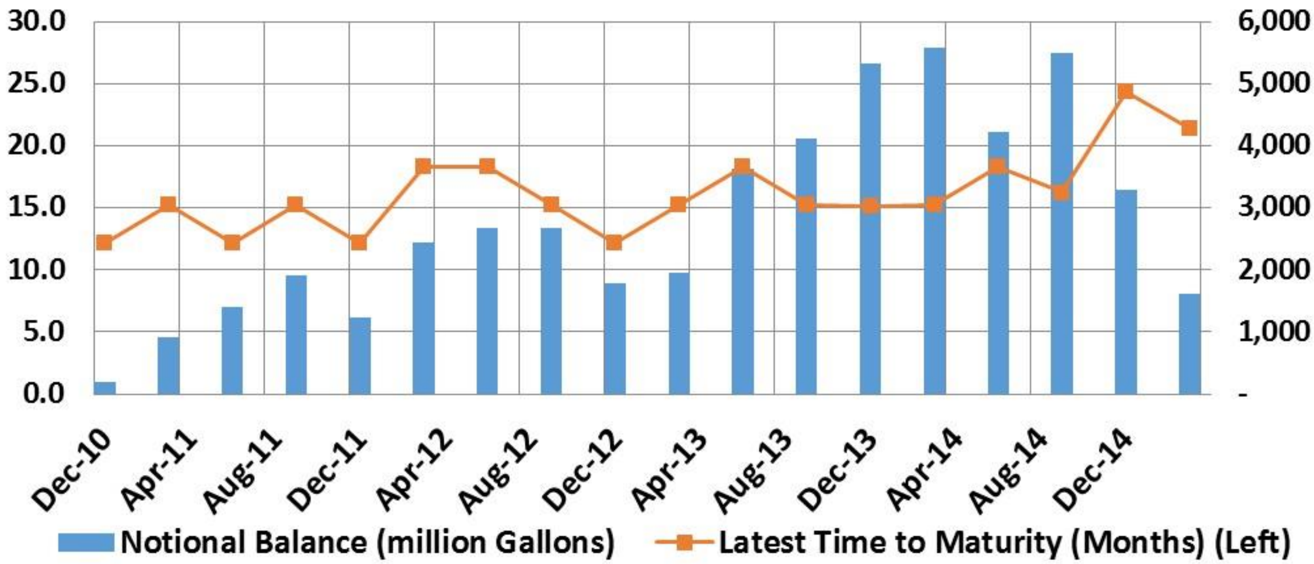


Table 4. Hedging policies for Delta and other airlines

The table describes hedge ratios for Delta and other publicly traded U.S. airlines from 2009 through 2015. Hedge ratios are defined as the percentage of next quarters anticipated fuel consumption hedged by petroleum-product based derivatives. Columns 1 through 9, respectively, list hedge ratios for Delta, AirTran, Alaskan, American, Hawaiian, JetBlue, US Airways, Southwest, and United while each is in our sample. Though SkyWest is a publicly traded U.S. airline, it is a contractor that operates small regional flights for larger airlines. As such, its fuel expenses are reimbursed by the contracting airline. Therefore, it has no need for a hedging policy.

Quarter Ending	Hedge Ratio for:											
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
	DAL	AAI	ALK	AAL	FRNT	HA	JBLU	LCC	LUV	SAVE	SKYW	UAL
Jun-16	4%		50%	0%		40%	24%		71%	0%	0%	12%
Mar-16	1%		47%	0%		50%	0%		60%	0%	0%	12%
Dec-15	12%		50%	0%		35%	0%		0%	0%	0%	17%
Sep-15	19%		50%	0%		50%	15%		0%	23%	0%	23%
Jun-15	20%		50%	0%		47%	14%		65%	19%	0%	22%
Mar-15	23%		50%	0%		50%	17%		0%	35%	0%	15%
Dec-14	46%		50%	0%		39%	17%		0%	35%	0%	22%
Sep-14	100%		50%	0%		65%	27%		20%	29%	0%	39%
Jun-14	72%		50%	0%		52%	23%		41%	50%	0%	21%
Mar-14	100%		50%	16%		47%	13%		34%	0%	0%	22%
Dec-13	100%		50%	19%		36%	16%	0%	43%	0%	0%	24%
Sep-13	86%		50%	40%		36%	27%	0%	48%	21%	0%	45%
Jun-13	61%		50%	34%		38%	26%	0%	93%	17%	0%	47%
Mar-13	40%		50%	28%		55%	18%	0%	82%	0%	0%	32%
Dec-12	47%		50%	21%		63%	5%	0%	12%	5%	0%	31%
Sep-12	58%		50%	39%		67%	23%	0%	29%	10%	0%	44%
Jun-12	47%		50%	40%		66%	23%	0%	46%	19%	0%	45%
Mar-12	42%		50%	32%		65%	20%	0%	0%	8%	0%	34%
Dec-11	32%		50%	21%		62%	27%	0%	6%	40%	0%	29%
Sep-11	40%		50%	52%		56%	40%	0%	45%	38%	0%	47%
Jun-11	35%		50%	48%		56%	43%	0%	50%	3%	0%	41%
Mar-11	25%	63%	50%	38%		56%	38%	0%	35%		0%	36%
Dec-10	38%	52%	50%	35%		59%	32%	0%	52%		0%	28%
Sep-10	37%	58%	50%	40%		53%	43%	0%	40%		0%	55%
Jun-10	35%	64%	50%	42%		60%	47%	0%	48%		0%	72%
Mar-10	28%	45%	50%	34%		56%	42%	0%	44%		0%	49%
Dec-09	22%	41%	50%	24%		50%	60%	0%	50%		0%	36%
Sep-09	17%	55%	50%	31%		54%	58%	0%	31%		0%	55%
Jun-09	20%	52%	50%	32%	20%	54%	12%	4%	37%		0%	73%
Mar-09	22%	45%	50%	32%	0%	54%	8%	9%	29%		0%	52%

Table 5. Delta and its peers

Airline	Ticker	Market State 2009 until 2016	ASM (million)	Market Share (%)
Delta Air Lines	DAL	Trading throughout the period. On October 29, 2008, Delta acquired Northwest airlines. Delta and Northwest began reporting jointly in January 2010.	108,016	16.28
United Airlines	UAL	On October 1, 2010, United acquired Continental Airlines. United changed its name from United to United Continental.	107,776	16.12
Southwest Airlines	LUV	Trading throughout the period	106,384	15.05
American Airlines	AAL	American Airlines parent, AMR Corp., filed for bankruptcy protection in November 2011. After its emergence from Chapter 11, It acquired US Airways Group and start trading under AAL from 12/6/2013. American and US Airways began reporting jointly as American Airlines (AAL) in July 2015	87,238	12.90
US Airways	LCC	Merged with American Airlines. Last trading day under LLC was 12/6/2013.	53,783	8.10
JetBlue Airways	JBLU	Trading throughout the period	33,596	4.98
Alaska Airlines	ALK	On November 12, 2010, SkyWest, Inc. completed its acquisition of ExpressJet airlines	25,579	3.89
AirTran Airways	AAI	Stopped trading on May 2, 2011 after being acquired by Southwest Airlines. Southwest and AirTran began reporting jointly in January 2015.	23,342	3.36
SkyWest, Inc.	SKYW	Trading throughout the period	15,880	2.29
Virgin America	VA	Offered to public in 14/11/2014 and has been trading ever since.	12,053	1.69
Frontier Airlines	FRENT	Frontier Airlines 's stock was suspended on April 22, 2008 after it filed for Ch.11. In October 2013, Frontier was sold to the private equity firm Indigo Partners.	10,462	1.65
Hawaiian Airlines	HA	Trading throughout the period	9,912	1.51
Spirit Airlines	SAVE	Went public in May 2011 and has been trading ever since	9,685	1.47
Allegiant Air	ALGT	Trading throughout the period	6,967	1.10

Table 6. Stock market event study results

This table presents the results of an event study of stock market reactions around Delta's announcement to purchase the Trainer refinery. Expected returns are estimated using the Market Model. The announcement date, April 30, 2012, is day zero. Panel A lists the cumulative abnormal return, CAR, over the (+1,-1) period while Panel B lists daily abnormal returns for the 7 days centered on the announcement date. The Patell z-score tests for statistical significance of abnormal returns and cumulative abnormal returns. Boldface denotes significance at the 10% level

Panel A: Cumulative Abnormal Return (CAR)

Window	CAR	Patell Z	p-value
(-1,+1)	**5.71%**	**1.309**	**0.0952**

Panel B: Abnormal Returns (AR)

Day	AR	Patell Z	p-value
-3	-1.73	-0.686	0.2463
-2	-1.67	-0.664	0.2533
-1	**3.61**	**1.434**	**0.0758**
0	1.87	0.741	0.2294
1	0.23	0.093	0.4628
2	-1.46	-0.581	0.2805
3	1.91	0.758	0.2241

Table 7. Synthetic Control Method (SCM) results

The table shows the results of SCM of (Abadie & Gardeazabal, 2003). We construct a synthetic match for Delta:

$$\{w_i\}_{i \in Control\ Group} = argmin \sum_{t}^{T} \left(R_{Delta,t} - \sum_{i} w_i R_{i,t} \right)^2$$

subject to $\sum_i \omega_i = 1$ where [t, T] is the estimation window in the pre-acquisition period and ω_i is the weight assigned to the stock return of the airline i. Once ω_i for each airline in the control group is determined, the CAR_{Delta} (−k, +k) where k is number of days around the announcement is calculated as:

$$CAR(-1,+1)_{delta,SC} = \sum_{-1}^{+1} \left(R_{Delta,t} - \sum_{i} w_i R_{i,t} \right)$$

We repeat the same analysis replacing Delta with each other airline in the control group and calculate its CAR_i (−k, +k) over the same window. These CAR_i (−k, +k) help to construct a distribution of cumulative returns that is not caused by the treatment against which the significance of CAR_{Delta} (−k, +k) is tested. The pool of control units consists of public airlines, among those in table 6, that were actively trading at the time of the announcement. Namely, the pool consists of: Allegiant, United, SkyWest, Southwest, Jet Blue, Hawaiian, Alaskan, Spirit and U.S. Airways. The announcement was in April 30, 2012. We use observations from January 1, 2011 to 50 days before the announcement in the estimation window. We choose 50 days to avoid the possible effect of any leak before the announcement. Data on stock market returns come from CRSP.

	DAL	ALGT	ALK	HA	JBLU	LCC	LUV	SAVE	SKYW	UAL
		CAR(-1,1)								
	0.0511	0.0220	-0.0293	0.0077	-0.0015	-0.0049	0.0108	-0.0498	0.0170	-0.0548
Day		Abnormal Return								
-3	-0.008	-0.001	0.006	0.086	-0.017	0.027	-0.019	0.004	-0.030	-0.008
-2	-0.005	-0.010	-0.009	-0.001	0.005	0.033	0.023	0.031	0.006	-0.034
-1	0.019	0.012	-0.023	0.036	0.011	0.019	0.002	-0.014	0.003	-0.036
0	0.017	-0.018	0.004	-0.029	-0.007	-0.009	0.010	0.012	0.022	-0.012
1	0.015	0.029	-0.011	0.000	-0.006	-0.014	0.000	-0.048	-0.009	-0.007
2	-0.016	0.038	-0.027	0.002	0.006	0.023	-0.007	0.047	-0.018	-0.006
3	0.001	0.023	-0.006	-0.004	-0.010	0.038	-0.001	-0.065	0.018	-0.018
Airline		Weights on Each Airlines in the Control Group								
DAL	NA	0.000	0.070	0.000	0.198	0.674	0.219	0.201	0.000	0.602
ALGT	0.000	NA	0.395	0.000	0.109	0.000	0.133	0.267	0.497	0.144
ALK	0.022	0.454	NA	0.325	0.475	0.000	0.402	0.167	0.228	0.000
FRENT	0.000	0.000	0.000	NA	0.013	0.031	0.108	0.107	0.000	0.116
HA	0.094	0.062	0.120	0.009	NA	0.101	0.000	0.000	0.000	0.000
JBLU	0.230	0.021	0.000	0.146	0.205	NA	0.000	0.000	0.000	0.101
LCC	0.201	0.118	0.319	0.284	0.000	0.000	NA	0.080	0.055	0.038
LUV	0.078	0.072	0.039	0.085	0.000	0.000	0.023	NA	0.220	0.000
SKYW	0.041	0.115	0.058	0.010	0.000	0.000	0.046	0.179	NA	0.000
UAL	0.335	0.158	0.000	0.142	0.000	0.194	0.068	0.000	0.000	NA

Table 8. Bond market event study results

This table presents bond market event study results around Delta's April 30, 2012 announcement to purchase the Trainer refinery. Deltas returns are compared against three benchmarks: all other airline bond returns, returns from a sample of all bonds matched to each Delta bond on maturity and credit rating, and returns from airline bonds matched on maturity and rating. Panel A describes raw and standardized returns for the four groups in our sample. R (SR) denotes raw (standardized) returns. Panels B tests mean and 0median differences between Deltas and various benchmarks returns using the Students T and Wilcoxon Signed Rank tests, respectively. P-values from those tests are reported beside mean and median differences. Panel C replicates these tests for standardized returns.

Panel A: Descriptive Statistics

Benchmark	Pct+	Mean Raw	Median STD	Mean Raw	Median Std
Delta	0.9333	0.0104	1.2367	0.0096	1.2213
Airlines	0.7265	0.0128	0.3668	0.0065	0.3746
Full	0.6641	0.0042	0.2725	0.0025	0.2496

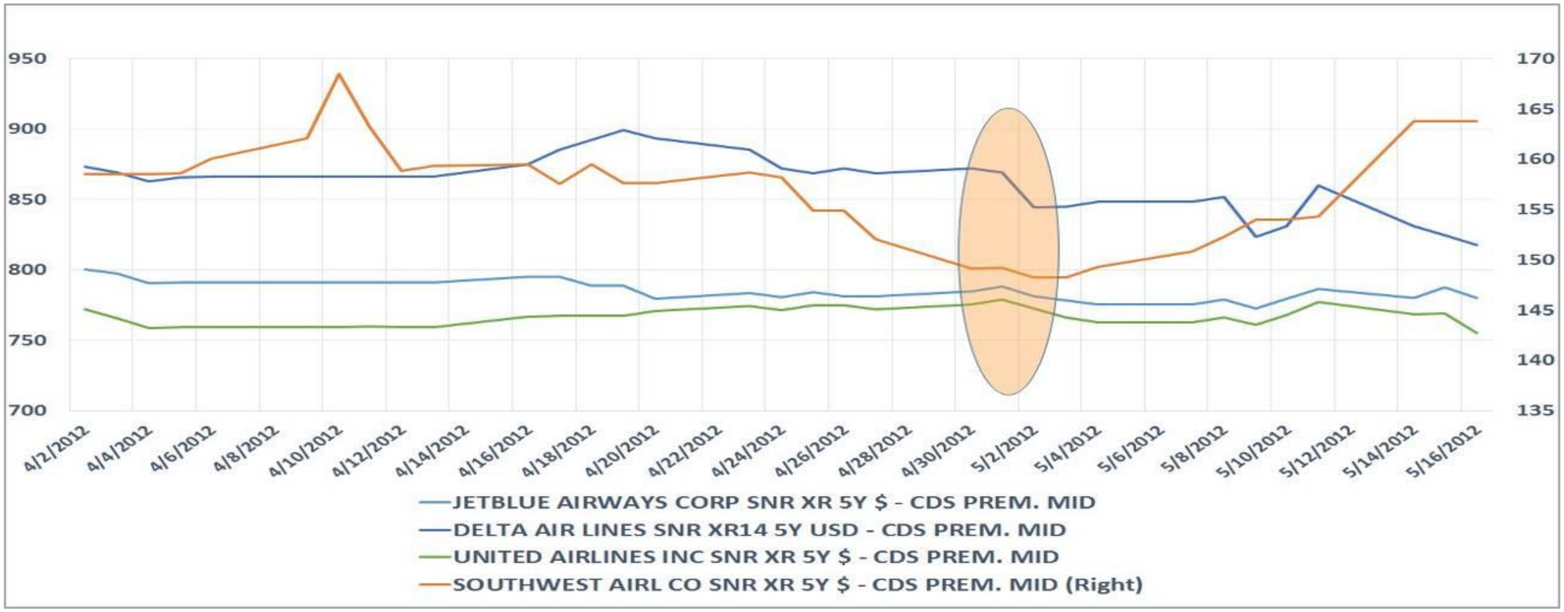
Panel B: Standardized Returns

Benchmark	Dif(Means)	Dif(Medians)	Signed Rank S p-value	Student's t p-value
Airlines	0.8959	0.9274	<.0001	<.0001
Matched	0.8516	0.8517	<.0001	<.0001
Airlines_Matched	1.0263	1.2776	<.0001	<.0001

Panel C: Raw Returns

Benchmark	Dif(Means)	Dif(Medians)	Signed Rank S p-value	Student's t p-value
Airlines	-0.0019	-0.0031	0.2434	0.1974
Matched	0.0047	0.0040	0.0064	0.0026
Airlines_Matched	0.0071	0.0084	<.0001	0.0002

Figure 6. Daily spreads of credit default swaps



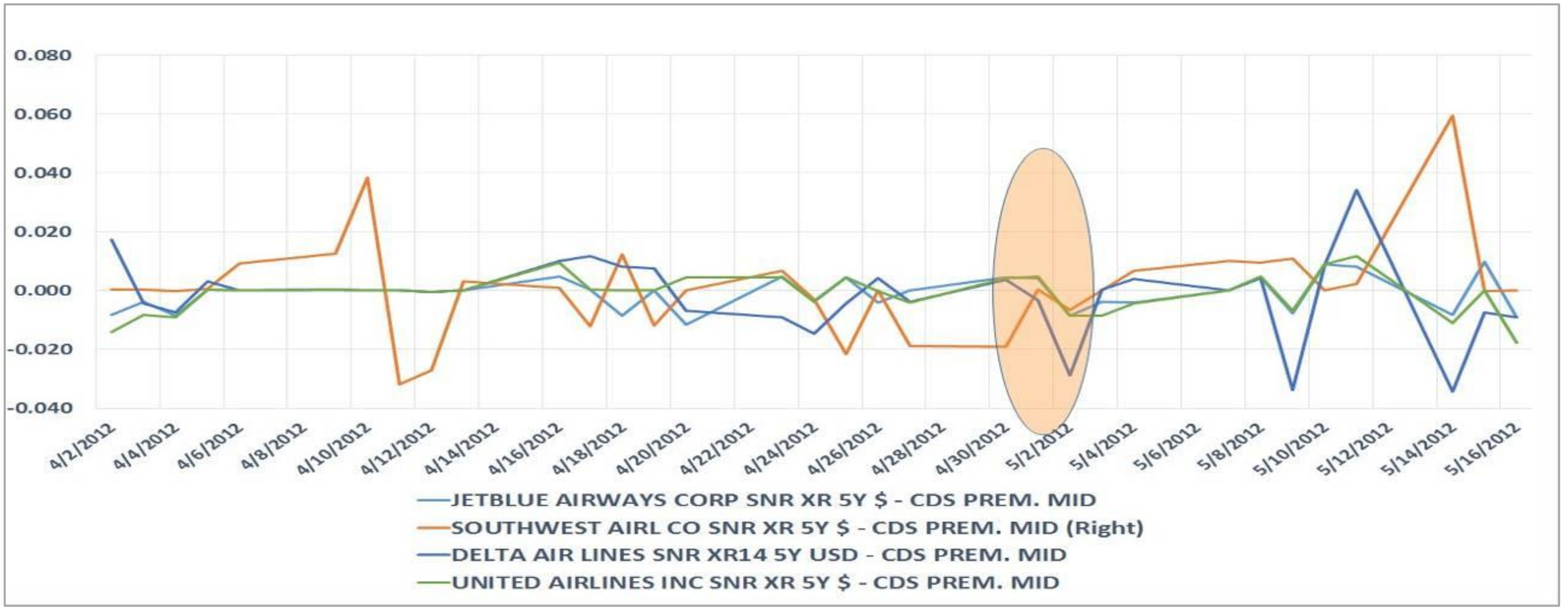


Figure 7. Rolling standard deviations with and without Trainer refinery

The figure shows the rolling standard deviation according to the breakdown in the following equation:

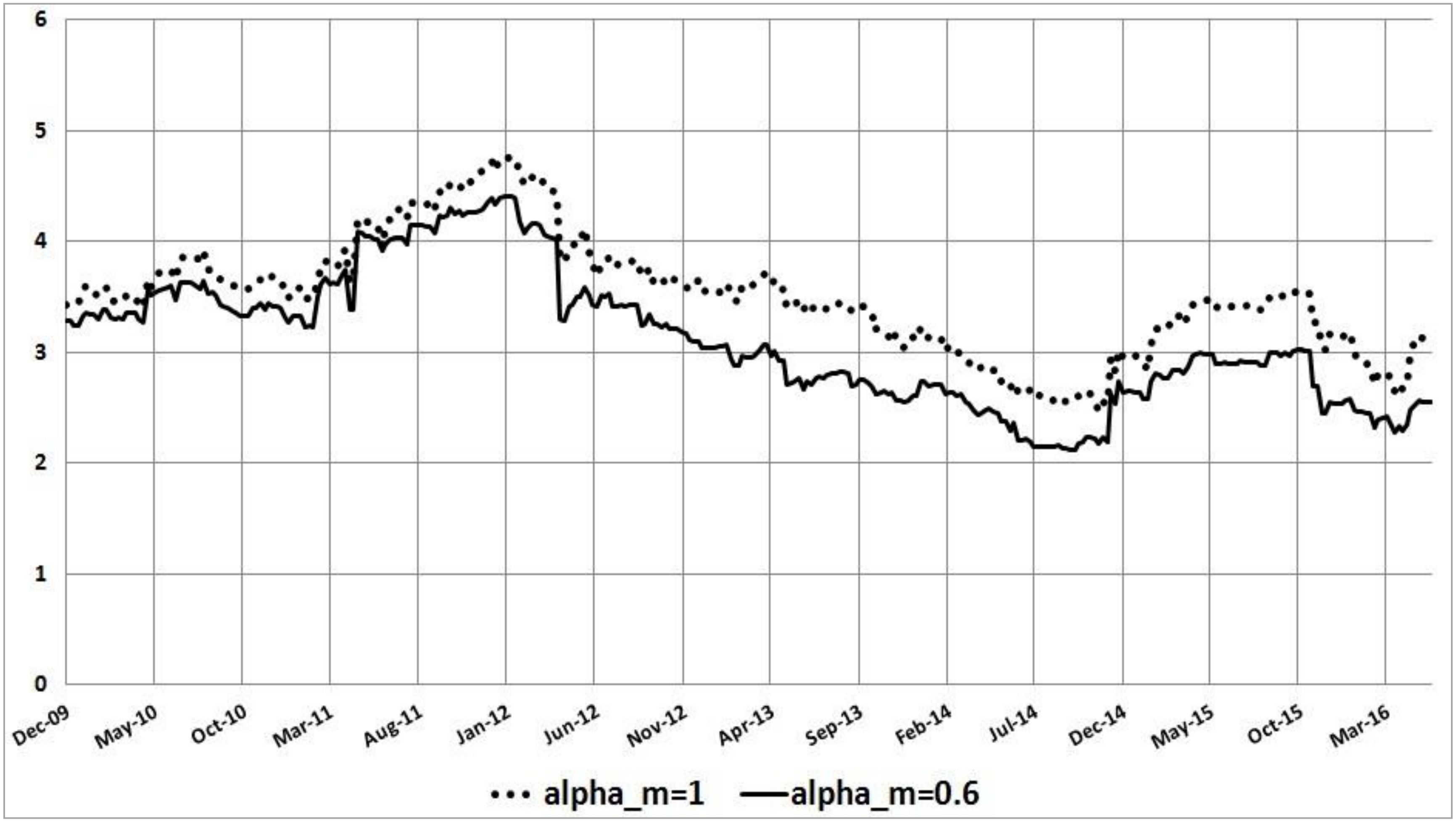


Table 9. Variability of airlines' jet fuel cost

Absolute variability is the standard Deviation of the change in per-gallon fuel cost. Relative standard deviation is the absolute variability divided by the standard deviation of the change in jet fuel price. All standard deviation is calculated using monthly data of airlines fuel cost collected by the Bureau of Transportation Statistics (BTS). In Delta (Adjusted), we remove the outlier of the first quarter of 2015 when Delta incurred a huge loss in its hedging program after the oil price slump (refer to Figure 4) was removed.

	Absolute Variability			Relative Variability	
	Pre-Trainer (A)	Post-Trainer (B)	Ratio (B/A)	Pre-Trainer	Post-Trainer
Jet Fuel	0.146	0.148	1.010	1	1
Delta	0.169	0.451	2.668	1.155	3.050
Delta (Adjusted)	0.169	0.152	0.900	1.155	1.029
American	0.134	0.119	0.888	0.919	0.808
Allegiant	0.134	0.136	1.015	0.916	0.920
Alaska	0.155	0.152	0.976	1.061	1.025
Frontier	0.168	0.153	0.910	1.145	1.032
Hawaiian	0.116	0.112	0.962	0.793	0.755
JetBlue	0.117	0.138	1.178	0.798	0.931
US Airways	0.122	0.130	1.064	0.834	0.879
Southwest	0.128	0.127	0.993	0.877	0.862
Spirit	0.360	0.261	0.727	2.457	1.768
SkyWest	0.181	0.163	0.900	1.238	1.103
United	0.126	0.116	0.922	0.858	0.783
Virgin America	0.128	0.112	0.873	0.875	0.757

Table 10. Delta's equity exposure

The table shows the result of the following regression:

$$R_{Delta,t} = \alpha + \beta_m R_{m,t} + \beta_c R_{c,t} + \beta_o R_{o,t} + \beta_p post_t + \beta_{po} post_t \times R_{c,t} + \beta_{po} post_t \times \beta_o R_{o,t} + \beta_{ch} HR_{Delta} \times R_{c,t} + \beta_{oh} HR_{Delta} \times R_{o,t} + \epsilon_{Delta,t}$$

$post_t$ is a dummy for the post-Trainer period. $R_{m,t}$ is the log return on S&P 500 as a proxy for the market portfolio. $R_{c,t}$ is the log return on the crack spread, measured by the difference between jet fuel price and oil price. $R_{o,t}$ is the log return on the price of WTI or Brent oil benchmark. HR_{Delta} is the last hedging ratio observed at time t. W eekly data from 6/05/2009 to 3/25/2016 were used for the estimation. Price data were obtained from CRISP and hedging ratios were obtained from the companies' quarterly filings. Appendix A shows how we obtain hedging ratios.

Dependent Variable: DLOG(P_DAL)

	WTI		Brent		WTI		Brent	
Variable	Coeff.	Prob.	Coeff.	Prob.	Coeff.	Prob.	Coeff.	Prob.
C	-0.002	0.667	-0.002	0.727	0.001	0.854	0.002	0.708
DLOG(SP500)	1.794	0.000	1.772	0.000	1.532	0.000	1.464	0.000
RC	-0.035	0.361	-0.026	0.543	0.032	0.419	0.028	0.541
RO	-0.495	0.000	-0.492	0.000	-0.365	0.002	-0.316	0.014
POST	0.005	0.429	0.004	0.460	0.002	0.709	0.002	0.735
POST*RC	-0.010	0.817	-0.017	0.710	-0.080	0.036	-0.067	0.084
POST*RO	0.187	0.161	0.217	0.128	0.359	0.001	0.344	0.002
HR*RO					0.016	0.798	-0.010	0.869
HR*RC					-0.562	0.004	-0.520	0.012
R-squared	0.311		0.293		0.272		0.242	
Adjusted R-squared	0.298		0.280		0.253		0.223	

White Heteroskedasticity-Consistent Standard Errors & Covariance

Sample (Weekly): 1/16/2009 3/25/2016

observations: 376

Table 11. Equity exposures for other airlines

The table shows the result of the following regression:

$$R_{i,t} = \alpha + \beta_m R_{m,t} + \beta_c R_{c,t} + \beta_o R_{o,t} + \beta_p post_t + \beta_{po} post_t \times R_{c,t} + \beta_{po} post_t \times \beta_o R_{o,t} + \beta_{ch} HR_i \times R_{c,t} + \beta_{oh} HR_i \times R_{o,t} + \epsilon_{i,t}$$

$post_t$ is a dummy for the post-Trainer period. $R_{m,t}$ is the log return on S&P 500 as a proxy for the market portfolio. $R_{c,t}$ is the log return on the crack spread, measured by the difference between jet fuel price and oil price. $R_{o,t}$ is the log return on the price of WTI or Brent oil benchmark. HR_i is the last hedging ratio observed at time t. Weekly data from 6/05/2009 to 3/25/2016 were used for the estimation. Price data were obtained from CRSP and hedging ratios were obtained from the companies' quarterly filings. Appendix A shows how we obtain hedging ratios. Alaska airline (ALK) and Skywest (SKYW) have no hedging ration in their regressions. ALK has a constant hedging ratio throughout the period and Skywest is a contractor that operates small regional flights for larger airlines. As such, its fuel expenses are reimbursed by the contracting airline. Therefore, it has no need for a hedging policy.

	C	RM	RC	RO	POST	POST x RC	POST x RO	HR x RC	HR x RO	R2	Adj.R2
DLOG(P_HA)											
Coeff.	-0.0023	1.6875	0.0575	0.9499	0.0067	-0.0223	-0.0957	-0.0784	-2.4646	0.2894	0.2709
Prob.	0.5487	0.0000	0.7063	0.0651	0.2465	0.6158	0.4899	0.7747	0.0079		
DLOG(P_JBLU)											
Coeff.	-0.0015	1.6490	-0.0438	-0.5439	0.0040	0.0069	0.2267	0.0351	0.3392	0.3040	0.2859
Prob.	0.6732	0.0000	0.0935	0.0008	0.4049	0.8291	0.0932	0.7296	0.4128		
DLOG(P_LCC)											
Coeff.	0.0038	2.1841	0.0132	-0.8455	-0.0034	-0.0698	0.5848	0.9575	14.9677	0.2761	0.2473
Prob.	0.5320	0.0000	0.8449	0.0000	0.6799	0.4061	0.0169	0.5150	0.0420		
DLOG(P_LUV)											
Coeff.	-0.0004	1.3266	-0.0043	-0.2849	0.0044	-0.0289	0.0284	0.0540	-0.1103	0.3866	0.3707
Prob.	0.8788	0.0000	0.8933	0.0037	0.2036	0.3330	0.7473	0.4350	0.5926		
DLOG(P_UAL)											
Coeff.	0.0048	1.8603	0.0503	-0.6308	-0.0052	-0.0836	0.3601	0.0288	-0.0643	0.2517	0.2322
Prob.	0.3676	0.0000	0.6139	0.0744	0.4242	0.2411	0.0847	0.8461	0.9279		
DLOG(P_SAVE)											
Coeff.	0.0027	1.6133	-0.0600	-0.5990	0.0055	-0.0403	0.0922	0.3201	1.2732	0.2546	0.2185
Prob.	0.6876	0.0000	0.6217	0.0511	0.4768	0.7361	0.8050	0.3315	0.1811		
DLOG(P_ALGT)											
Coeff.	0.0021	0.8833	-0.0225	-0.2949	0.0002	0.0045	0.1639			0.1632	0.1472
Prob.	0.4652	0.0000	0.3222	0.0001	0.9518	0.8833	0.1238				
DLOG(P_ALK)											
Coeff.	0.0033	1.5329	0.0410	-0.4294	-0.0012	-0.0619	0.1031			0.4601	0.4495
Prob.	0.2569	0.0000	0.0672	0.0000	0.7697	0.1048	0.3370				
DLOG(P_SKYW)											
Coeff.	0.0014	-0.3236	0.0130	0.0073	-0.0016	-0.0692	-0.1474			0.0205	0.0012
Prob.	0.7395	0.0920	0.6282	0.9535	0.8382	0.2773	0.4489				

Sample (adjusted): 6/05/2009 3/25/2016
White Heteroskedasticity-Consistent Standard Errors & Covariance

Table 12. Bond yield difference-in-difference results

The table reports the result of a difference-in-differences OLS regression of airline bond yield spreads. The dependent variable, *spread*, is the spread above the comparable maturity Treasury security. The three difference-in-differences dependent variables are three indicator variables. *Dal* equals 1 if the Delta is the borrower and 0 otherwise; *post* equals 1 if the bond trades after April 30, 2012 and 0 otherwise; and *dal_post* is the interaction between the two. Control variables include the number of years remaining till maturity, daily volume traded, logged assets at the beginning of the quarter, book leverage at the beginning of the quarter, market to book ratio at the beginning of the quarter, hedge ratio at the beginning of the quarter, S&P or Moody's credit rating at the beginning of the quarter, an indicator variable equal to 1 if the bond trades during the rising oil price environment of ____________ to ___________ and 0 otherwise, an indicator variable equal to 1 if the bond trades during the falling oil price environment of ____________ to ___________ and 0 otherwise, and indicator variables for various bond characteristics including whether the bond has call, put, convertibility provisions, credit enhancements, whether it specifies collateral, whether it is a senior note, corporate debenture, corporate convertible, or asset backed security, and whether it pays quarterly coupons. Column 1 includes all variables, column 2 swaps the oil_up and oil_down indicators for year fixed effects; Column 3 includes firm-fixed effects; Column 4 includes bond fixed effects; Column 5 truncates at the 1 and 99% levels rather than the 5 and 95% levels as do the other columns; Columns 6 and 7 respectively investigate investment grade and non-investment grade bonds, separately; and Column 8 uses data from only the two years centered on quarters 2 and 3 of 2012 whereas the other columns employ the 7 years centered on those quarters. Standard errors are clustered at the bond level. T-statistics are reported below estimated coefficients. *, **, and *** denote statistical significance at the 10, 5, and 1 percent levels.

	Dependent Variable							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Independent Variable	spread	spread	spread	spread	spread	spread	spread	spread
Delta*Post	-1.319***	-1.334***	-1.208**	-0.965**	-6.582**	-0.477	-2.622***	-0.612
	(-2.812)	(-3.269)	(-2.566)	(-2.203)	(-2.242)	(-1.572)	(-2.804)	(-1.231)
Delta	1.281*	1.176*	1.385**	4.217***	6.185**	0.302	3.276**	0.751
	(1.933)	(1.948)	(2.042)	(10.901)	(2.283)	(0.556)	(2.635)	(0.953)
Post	0.163	0.176	0.234	0.590	5.684*	-0.727***	1.371	0.218
	(0.363)	(0.730)	(0.494)	(1.200)	(1.911)	(-5.508)	(1.302)	(0.500)
years remaining	-0.163***	-0.146***	-0.189***	0.206	-0.384**	-0.266***	-0.195***	-0.305***
	(-5.220)	(-4.769)	(-4.527)	(1.097)	(-2.503)	(-6.088)	(-3.921)	(-4.618)
trading volume	0.000	-0.000	0.000	-0.000	0.000	0.000	-0.000	-0.000
	(0.003)	(-0.517)	(0.288)	(-0.746)	(0.569)	(1.524)	(-0.764)	(-0.780)
logged assets	-0.849***	-0.722***	-2.583*	-1.103***	-1.788**	-0.217	-1.284***	-1.263**
	(-3.672)	(-3.074)	(-1.974)	(-4.376)	(-2.020)	(-1.327)	(-4.409)	(-2.247)
book leverage	0.310	0.213	-0.538	1.468*	-2.075	0.779	1.938	-2.111
	(0.437)	(0.269)	(-0.459)	(1.790)	(-0.507)	(1.004)	(0.864)	(-0.628)
market to book ratio	-0.002***	-0.001***	-0.002***	-0.001**	-0.002	-0.002***	-0.002	-0.007**
	(-4.011)	(-3.003)	(-3.561)	(-2.560)	(-1.068)	(-5.081)	(-1.273)	(-2.634)
hedge ratio	0.513	0.827**	0.167	0.187	-1.773	-0.159	1.313	-0.092
	(1.191)	(2.053)	(0.391)	(0.489)	(-0.800)	(-0.824)	(1.067)	(-0.088)
rating	0.348***	0.467***	0.314**	-0.641***	-0.421	0.349**	-0.180	0.316
	(2.905)	(4.148)	(2.157)	(-3.106)	(-0.953)	(2.162)	(-0.385)	(1.283)
oil_up	-0.755	-	-0.980*	-0.895**	-3.630	0.143	-0.758	-
	(-1.400)	-	(-1.770)	(-2.214)	(-1.332)	(0.253)	(-1.267)	-
oil_down	0.296	-	0.242	0.481	-0.392	0.206	0.148	-
	(1.233)	-	(1.098)	(1.322)	(-0.240)	(1.380)	(0.278)	-
put option	-6.371***	-6.587***	-7.009***	-	-17.858***	-	-5.939***	11.243***
	(-17.692)	(-15.184)	(-17.945)	-	(-13.791)	-	(-9.277)	(-10.600)
convert option	-1.839**	-1.905*	-2.316***	-	2.708	-	-2.899***	0.265
	(-2.039)	(-1.922)	(-2.804)	-	(1.063)	-	(-2.900)	(0.181)
covenants	-1.282***	-1.313***	-1.256***	-	-1.276*	-0.483	-1.277**	-1.343**
	(-4.132)	(-4.307)	(-3.907)	-	(-1.901)	(-1.447)	(-2.191)	(-2.339)
collateral	-0.447	-0.312	-0.477	-	-1.380*	-0.006	-0.305	-1.816***
	(-1.138)	(-0.810)	(-1.170)	-	(-1.698)	(-0.013)	(-0.506)	(-3.561)
senior	-0.041	0.004	-0.013	-	-0.561	0.319	-0.159	-0.656
	(-0.171)	(0.018)	(-0.053)	-	(-0.730)	(1.310)	(-0.321)	(-1.201)
enhancements	0.454**	0.527**	0.594**	-	-0.293	0.597**	-0.533	0.250
	(2.053)	(2.396)	(2.494)	-	(-0.316)	(2.445)	(-0.889)	(0.568)
call option	3.262***	3.061***	3.226***	-	5.402	2.972***	4.484***	9.568***
	(3.396)	(3.115)	(3.187)	-	(1.067)	(5.000)	(3.570)	(6.670)
corporate debenture	-0.753*	-0.779**	-0.866**	-	-0.475	-1.311**	0.178	-3.890***
	(-1.911)	(-1.992)	(-2.139)	-	(-0.676)	(-2.490)	(0.183)	(-6.308)
corporate convertible	7.674***	7.450***	7.923***	-	25.720***	-	10.634***	9.945***
	(4.850)	(4.403)	(5.131)	-	(3.546)	-	(6.132)	(5.042)
asset backed security	-2.928***	-2.661***	-3.004***	-	-3.846	-1.236***	-3.350***	-
	(-4.264)	(-4.059)	(-4.750)	-	(-1.582)	(-2.869)	(-3.362)	-
quarterly coupon	2.807***	2.772***	2.209***	-	9.321***	-	2.973*	0.968*
	(5.855)	(5.722)	(4.145)	-	(2.806)	-	(1.958)	(1.740)
Constant	10.499***	9.087***	30.224*	12.113***	21.886***	4.318**	13.932***	15.614***
	(4.945)	(3.345)	(1.984)	(4.258)	(3.100)	(2.150)	(2.893)	(3.124)
Bond FE	No	No	No	Yes	No	No	No	No
Firm FE	No	No	Yes	No	No	No	No	No
Year FE	No	Yes	No	No	No	No	No	No
Window	32 quarters	32 quarters	32 quarters	32 quarters	32 quarters	32 quarters	32 quarters	8 quarters
Rating	All	All	All	All	All	Investment	Noninvestment	All
Truncated	5/95	5/95	5/95	5/95	1/99	5/95	5/95	5/95
Observations	16,639	16,639	16,639	16,639	18,272	9,714	6,925	3,932
R-squared	0.483	0.502	0.492	0.589	0.476	0.698	0.401	0.538

Table 13. Loan spread difference-in-difference results

The table reports the result of a difference-in-differences OLS regression of loan spreads on newly issued credit facilities for airlines. The dependent variable, *allindrawn*, is the spread above the comparable maturity LIBOR rate. The three difference-in-differences dependent variables are three indicator variables. *Dal* equals 1 if the Delta is the borrower and 0 otherwise; *post* equals 1 if the loan is issued after April 30, 2012 and 0 otherwise; and *dal_post* is the interaction between the two. Control variables include the facility's maturity, an indicator variable equal to 1 if the loan includes collateral and 0 otherwise, an indicator variable equal to 1 if the loan is a revolving loan and 0 if it is a term loan, the amount borrowed, the number of participants and a constant. Standard errors are clustered at the firm level. t-statistics are reported below estimated coefficients. ** and *** denote statistical significance at the 5 and 1 percent levels.

	(1)
VARIABLES	Spread
Delta*Post	-70.438**
	(-2.543)
Delta	107.812**
	(2.913)
Post	-87.404
	(-1.235)
Maturity	-0.732
	(-1.602)
Collateral	157.342***
	(6.590)
D_Revolver	46.202
	(1.105)
Amount	0.000**
	(2.471)
Participants	-9.276
	(-1.114)
Constant	265.896***
	(9.439)
Observations	33
R-squared	0.616