Petroleum-Refining Industry Business Interruption Losses due to Hurricane Katrina

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Abstract

Hurricane Katrina had a significant destructive effect on the Gulf Coast’s petroleum-refining industry. In many cases, refineries sustained considerable damage and had to suspend operations for extended periods of time. Multiple Gulf Coast refineries filed substantial business interruption loss insurance claims following Hurricane Katrina’s disruption of their production. This paper presents a methodology to calculate refinery business interruption losses taking into account the effect of Hurricane Katrina on input and output market prices during the period of restoration. Our results indicate that adjusting for Hurricane Katrina’s effects on crude oil and petroleum product market prices significantly changes the magnitude of refinery business interruption loss claims.

KEYWORDS: Hurricane Katrina, business interruption loss, business interruption insurance, refinery margins, gasoline, petroleum, refinery

*Opinions expressed in this paper are solely those of the authors and do not necessarily represent the views of Cornerstone Research. We would like to thank Bradley Ewing and an anonymous reviewer for comments.
1 Introduction

Hurricane Katrina was one of the most destructive hurricanes in the history of the United States. In addition to the tragic loss of lives, Hurricane Katrina caused more economic damage than any recent catastrophe in the United States. In particular, Hurricane Katrina’s effect on the Gulf Coast’s petroleum refining industry was significant. Many refineries sustained considerable physical flood and wind damage to their equipment and facilities and had to suspend operations, some for extended periods of time. Between August 29 and September 8, 2005, approximately two million barrels a day of capacity were shut down, accounting for a substantial amount of Gulf Coast and U.S. refining capacity. Some refineries that suffered physical damage during this period also experienced lost profits and consequently filed business interruption insurance claims to recover or offset those amounts.

Business interruption insurance is a means to recoup earnings lost as a result of an occurrence of a covered risk that disrupts the insured’s business operations. Typically, the claimed lost profits due to business interruptions are calculated on the basis of historical production volumes and prices observed during the period of restoration. This approach is based on the assumption that the event causing the business disruption does not have a significant effect on input and output markets; therefore, prices observed during the interruption period accurately reflect the prices that would have existed had the interruption not occurred. This assumption did not apply to the petroleum refining industry after Hurricane Katrina. As a result of extensive damage to oil extraction and refining facilities in the Gulf Coast and the consequent reduction in market supply, prices of crude oil and petroleum products were higher immediately after the hurricane compared to prehurricane and historical levels. That is, crude oil and petroleum product prices observed in the days following Hurricane Katrina may not have

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1 According to Congressional Budget Office estimates, 570,000 or more people lost jobs at least temporarily, and the loss of physical capital approached $110 billion. See Congressional Budget Office, 2006, “The Budget and Economic Outlook: Fiscal Years 2007 to 2006,” p. 28.


3 For example, see Torpey (2004).

4 Hurricane Katrina made landfall in Louisiana on August 29, 2005. The average U.S. Gulf Coast conventional gasoline spot price between August 22 and August 26, 2005, was $1.83 per gallon. On August 30, 2005, U.S. Gulf Coast conventional gasoline spot price reached $2.91 per gallon. The average U.S. Gulf Coast heating oil spot price between August 22 and August 26, 2005, was $1.81 per gallon. On September 1, 2005, U.S. Gulf Coast heating oil spot price reached $2.16 per gallon. The average West Texas Intermediate crude oil spot price between August 22 and August 26, 2005, was $66.3 per barrel. Crude oil price reached $69.9 per barrel on August 30, 2005.
reflected the expected prices that would have existed in the absence of the hurricane, thus using them to calculate the refineries’ lost profits may overstate the business losses due to the interruption.

The purpose of this paper is to present a methodology to calculate the business interruption loss of a refinery damaged by Hurricane Katrina, taking into account the hurricane’s impact on crude oil and petroleum product markets. The approach statistically determines the duration and the magnitude of Hurricane Katrina’s effect on the spread between crude oil and petroleum products prices and estimates what the price spreads would have been in the absence of the hurricane. These estimated price spreads are then used along with estimates of production volumes to calculate the lost profits.

The results indicate that Hurricane Katrina’s effect on the spread between crude oil and petroleum product prices lasted for two weeks. During this period of significant supply disruption, the observed average price spread was approximately 180 percent higher than estimates of what it would have been in the absence of the hurricane. If the actual price spreads, rather than the spreads adjusted for the effect of Hurricane Katrina, are used to estimate the two-week business loss of a hypothetical refinery with a capacity of 150 thousand barrels a day, the refinery’s lost profits would be overstated by $36 million.

An insurance policy’s language determines whether the calculation of business interruption losses include the wider market impact of a catastrophic event. However, standard business interruption policies either do not address this issue or have ambiguous language that is open to interpretation. In addition, case law provides little guidance. For example, in *Levitz Furniture Corp. v. Houston Casualty Co.*, the court found that “business interruption loss earnings may include sales [the insured] would have made in the aftermath of the [peril] had it been open for business during that period.” In contrast, the court in *Prudential LMI Commercial Ins. Co. v. Colleton Enterprises, Inc.* decided that the policyholder could not take advantage of any increase in earnings due to the favorable economic effects of a hurricane. This issue has important policy implications regarding the pricing and availability of business interruption policies. These policy implications are discussed in the conclusion.

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2 Hurricane Katrina’s Impact on the Refining Industry

The Gulf Coast region is the center of the U.S. oil and petroleum refining industries. The region provides over 50 percent of the U.S. crude oil production and almost 50 percent of the national refining capacity. The region also receives 60 percent of total U.S. crude oil imports and sends over 1.5 billion barrels of refined petroleum products per year to other regions of the U.S., primarily via pipelines.

Hurricane Katrina’s effect on the Gulf Coast oil production and petroleum refining industries was significant. The Hurricane destroyed 46 oil production platforms and damaged 20 others as well as 100 pipelines. Initially, 95 percent of daily crude oil production in the Gulf of Mexico, accounting for approximately 2 percent of the world’s production, was shut down. Over 50 percent of the region’s daily crude oil production capacity was still nonoperational before Hurricane Rita forced additional shut-ins. Similarly, Hurricane Katrina shut down 25 percent of the Gulf Coast refining capacity, accounting for over 10 percent of the U.S. refining capacity. Although half of this capacity came back on line in two weeks, the refinery shut downs caused a significant drop in U.S. gasoline production during early September 2005. Figure 1 below summarizes Hurricane Katrina’s disruption to the U.S. Gulf Coast refinery capacity.

These supply disruptions had varying degrees of impact on crude oil and petroleum product prices due to the different dynamics of crude oil and petroleum product markets. For example, the weekly average spot price of conventional gasoline immediately after the hurricane was 50 percent higher than the average price in the week before the hurricane (see Figure 1). In comparison, this

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12 Ibid.
13 According to EIA data, the average daily conventional gasoline production in the first week of September 2005 was 22 percent lower than the average daily production during August 2005.
differential for crude oil was 4 percent. Further, the duration of the price spike was longer in the gasoline market than in the crude oil market. By September 2, 2005, crude oil prices were within 1 percent of the average prices observed in the week before the hurricane while gasoline prices were still 30 percent higher.

**Figure 1: Gulf of Mexico Shut-in Refinery Capacity and Conventional Gasoline Price: August 1, 2005–October 31, 2005**

![Figure 1: Gulf of Mexico Shut-in Refinery Capacity and Conventional Gasoline Price: August 1, 2005–October 31, 2005](image)

Source: Energy Information Administration, Minerals Management Service

### 3 Calculation of Refinery Business Losses

Calculation of a refinery’s business loss due to the hurricane-related shut down is based on estimating the amount of petroleum products the refinery would have produced and the margin the refinery would have earned had Hurricane Katrina not occurred. That is, the calculation should capture the operations of the refiner as if the refinery had not been damaged and as if the hurricane had not disrupted the Gulf Coast’s oil and petroleum production. The volume that the refinery would have produced had its operations not been interrupted ("but-for" production) can be estimated with reasonable accuracy based on the refinery’s historical production patterns. In the case of refineries, this estimation is relatively uncontroversial since refineries have fixed capacities in the short run and operate
close to full capacity with only moderate fluctuations. Data on capacities and historical utilization rates are readily available from refineries or public sources such as the Energy Information Administration (EIA) and company annual reports.\textsuperscript{14} The analysis presented here is based on a hypothetical refinery with a capacity of 152 thousand barrels per day and 93 percent utilization.\textsuperscript{15}

Estimation of the refinery’s profit margin in the absence of Hurricane Katrina (“but-for” spreads) is more complex for several reasons. First, observed spreads between crude oil and petroleum product prices cannot be used because these prices include Hurricane Katrina induced spikes, hence they would overstate the refinery’s margins during the period of interruption. Further, observed prices may not reflect the refinery’s actual margins immediately after the hurricane since the transaction volume at those prices was very low. Similarly, using historical price spreads instead of the observed price margins after Hurricane Katrina may not be appropriate because these spreads are highly variable over time depending on market conditions for crude oil and petroleum products. For example, EIA data show that the weekly spread between U.S. Gulf Coast gasoline and crude oil prices in 2004 varied between 42.0 and –1.3 cents per gallon. Further, the average margins based on past prices are sensitive to the historical period considered, and there is no theoretical basis for choosing the appropriate historical time period. The approach of this paper is to econometrically estimate the price spreads during the period of restoration and to use the estimated spreads as a proxy for the but-for refinery margins.

The margin estimates are obtained from an econometric forecasting model that considers market trends and other relevant economic factors that may affect the price spreads. The model also produces statistical confidence intervals for the resulting estimates. Based on these confidence intervals, it is possible to statistically determine the duration of Hurricane Katrina’s impact on the price spreads. Specifically, Hurricane Katrina is found to have an effect on the market when the observed price spread is larger than the upper bound of the confidence interval around the predicted spread. The magnitude of the effect is the difference between the observed and the estimated but-for spread.

The “3-2-1 crack spread” is used as a proxy for the hypothetical refinery’s gross margin. This measure is based on the product mix of a refinery that converts crude oil into gasoline and distillates (e.g., heating oil) in an approximate two-to-

\textsuperscript{14} In an actual claim analysis, internal refinery documents such as historical yield reports and maintenance schedules can be used to arrive at a more precise estimate of product mix and volumes.

\textsuperscript{15} Based on EIA data, the average operating capacity of Gulf Coast refineries in 2005 was 152 thousand barrels per day. The average utilization rate for refineries in the U.S. between 2000 and 2004 during September was 93 percent.
The 3-2-1 crack spread applicable to a Gulf Coast refinery is calculated using the EIA’s West Texas Intermediate (WTI) crude oil, the Gulf Coast conventional regular gasoline, and the Gulf Coast No. 2 heating oil spot price series.

The forecasting model includes past values of the crack spread, contemporaneous crude oil prices, past values of Gulf Coast gasoline inventory levels, and seasonality indicators as explanatory variables. The autoregressive term in the model (i.e., the past values of the crack spread) captures the dynamic behavior of the price spread while crude oil prices represent input costs. Gasoline inventories provide a measure of demand and production balance, hence they are good indicators of market pressure on price changes. This specification is chosen from 30 alternative specifications that included explanatory variables such as petroleum product imports, gross inputs into refineries, U.S. gasoline stocks, as well as a number of other economic variables. Root mean squared error of cross validation (RMSECV) is utilized for model selection. The candidate models are estimated using weekly data between January 1, 2000 and August 25, 2005 and out-of-sample predictions for four two-month time periods starting on November 1, 2005, are generated. The performance of each model’s prediction is then compared to actual data using the root mean squared error. The model with the lowest average root mean squared error (i.e., the model whose predictions have the least amount of deviation from the actual data) is selected.

Table 1 below shows the parameter estimates of the selected model. All variables in the regression have the expected signs and are statistically significant. As expected, the price spread has a tendency to revert back to a baseline level as implied by the positive but less than one coefficient estimate on the autoregressive term. The negative coefficient estimate on lagged gasoline stocks indicates that margins are higher when gasoline inventories are low.

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16 According to EIA data, U.S. Gulf Coast refineries’ outputs in 2004 consisted of 44 percent gasoline, 24 percent distillates, and 32 percent other products.

17 For example, see Pindyck (1994) for an empirical study of the relationship between inventories and short-run commodity prices.

18 We use weekly data because gasoline stocks are reported weekly. We start our cross validation on November 1, 2005, in order to exclude Hurricane Rita’s impact on oil and oil product markets from our model selection mechanism.

19 The model was estimated using the ARIMA procedure in SAS.

20 The augmented Dickey Fuller test indicates that the crack spread series are stationary. Further, based on the facts that autocorrelation function tapers off and the partial autocorrelation function cuts off after one lag, AR(1) appears to be the appropriate specification.
Table 1: Crack Spread Estimation Results

<table>
<thead>
<tr>
<th></th>
<th>Estimate</th>
<th>Standard Error</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>5.30</td>
<td>1.53</td>
</tr>
<tr>
<td>Lagged Crack Spread</td>
<td>0.76</td>
<td>0.04</td>
</tr>
<tr>
<td>Gulf Coast Crude Oil Price</td>
<td>0.05</td>
<td>0.01</td>
</tr>
<tr>
<td>Lagged Gulf Coast Gasoline Stocks</td>
<td>-0.10</td>
<td>0.03</td>
</tr>
<tr>
<td>Winter Indicator</td>
<td>0.43</td>
<td>0.19</td>
</tr>
<tr>
<td>Spring Indicator</td>
<td>0.87</td>
<td>0.20</td>
</tr>
<tr>
<td>Summer Indicator</td>
<td>0.43</td>
<td>0.19</td>
</tr>
</tbody>
</table>

Notes: Gasoline stocks are measured in millions of barrels. Weekly data is used in the estimation.

This model can be used to dynamically predict price spreads under different market conditions, as summarized by the explanatory variables of the model. Although crude oil prices, inventory levels, and past price spreads are observed for the prediction period, their observed values do not reflect what the market conditions would have been in the absence of Hurricane Katrina because these variables were also impacted by Hurricane Katrina. To solve this problem, EIA’s forecasts of Gulf Coast crude oil prices and gasoline inventory levels for August and September 2005 are used. Since these forecasts were calculated before the hurricane, they reflect expectations of what Gulf Coast inventory levels and crude oil prices would have been but-for Hurricane Katrina. For the lagged crack spread variable, the last observation before Hurricane Katrina is used to estimate the first prediction, and then the model’s predicted values are used for the remaining lagged price variables. The but-for crack spreads constructed this way directly embody observed market dynamics, while adjusting for expected changes in other economic factors during the prediction period.

Figure 2 shows the actual and forecasted price spreads as well as the confidence interval for the relevant time period. The results indicate that Hurricane Katrina’s impact on price spreads lasted two weeks. By the week of September 12, 2005, the model’s forecast is not statistically different from the crack spreads based on the observed crude oil, gasoline, and heating oil prices. The average but-for crack spread during the two week period following Hurricane Katrina was $10.20. In comparison, the average observed crack spread during this period was 180 percent higher ($28.53).
The refinery’s lost earnings during the restoration period can be estimated with the forecasted crack spreads, assuming that the refinery was restored to full capacity within two weeks following Hurricane Katrina. Based on the forecasted margins, the business interruption loss of a refinery with a capacity of 152 thousand barrels a day and a utilization rate of 93 percent is $20 million. If, instead, the observed price spreads during this period are used to calculate the business interruption loss of the same refinery, the estimated loss would be $56 million, $36 million more than the estimate that accounts for the higher market prices due to the hurricane. Similarly, using various historical averages of the crack spreads yields disparate estimates of lost profits. For example, using the average crack spread in the prior 12 months implies $14 million in business interruption loss, while using the four-week average prior to the hurricane yields a $23 million loss, which is 15 percent higher than our estimate.

Half of the capacity affected by Hurricane Katrina came back online within two weeks after the hurricane. The calculation of the business interruption loss for a refinery that remained offline longer than two weeks is a more complicated problem because of Hurricane Rita, which also damaged multiple refineries and had a major impact on refining margins.
The analysis presented above could be extended to consider the net business interruption loss of a particular policy holder who may own other refineries that were not damaged by Hurricane Katrina. Since refineries in the Gulf Coast are owned by companies that also own refineries in other parts of the country and refining margin increases following the hurricane were observed in areas other than the Gulf Coast, some policy holders’ profits outside of the Gulf Coast could have been affected by the hurricane. The profits earned as a result of the hurricane-related supply disruptions in those other locations could be estimated in a manner similar to the one shown here. These estimates then can be used to determine the net business interruption loss for the policy holder; that is, the difference between profits lost at the damaged refinery and the profits potentially gained at other operations due to the hurricane’s effect on market prices.

22 In some cases, courts have considered the effects of an occurrence on all operations of a policy holder, provided that the interdependence of these operations can be demonstrated.

23 According to public reports, some insurance companies denied Hurricane Katrina business interruption claims because the policy holders’ aggregate operations effectively profited from the supply disruptions, and there was no actual loss. See National Underwriter, Property and Casualty, 2005, “Are Insurers Denying Oil B.I. Claims?” (December 19/26).
4 Conclusion

Catastrophic events that lead to supply disruptions can cause changes. In particular, they can cause increases in market prices, thus increases in profits for businesses that continue to operate during the event. Calculating a business loss as a result of such catastrophic events without accounting for the effect of those disruptions on prices and margins compensates the insured not only for the profits it would have made had the event not occurred, but also for the higher than normal profits that would have been earned if the business would have continued to operate during the event.

Gulf Coast refineries’ business interruption claims resulting from Hurricane Katrina related damage are examples where taking into account the wider market impact of the hurricane has a large impact on the magnitude of the claims. This paper presents a methodology to calculate refinery business interruption losses that accounts for the effect of Hurricane Katrina on input and output market prices during the period of restoration. The estimation is based on a dynamic model that reflects historical patterns of market dynamics as well as the expected changes in other economic factors during the prediction period. The model is used to estimate the duration and the magnitude of Hurricane Katrina’s impact on a hypothetical refinery’s gross margins. The results indicate that adjusting for Hurricane Katrina’s effects on crude oil and petroleum product market prices significantly changes the magnitude of refinery business interruption loss claims. If the compensation methods used to calculate the claims do not account for the higher market prices and margins caused by the hurricane, then the resulting claims would be substantially higher.

Allowing businesses to recover, under standard business interruption policies, windfall earnings due to the favorable economic conditions created by the peril has the unintended consequence of exposing insurers to additional market price risks related to supply disruptions. Once insurers appropriately account for their increased liabilities, they would likely raise the cost of business interruption insurance contracts. With higher premiums for business interruption insurance, some businesses would be priced out of the market and would not be able to obtain the level of coverage to complete their insurance portfolios. To avoid such a market contraction, business interruption policies should clearly define the scope of their coverage and specify how losses should be computed.
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