Jet Fuel-Heating Oil Futures Cross Hedging -Classroom Applications Using Bloomberg Terminal

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Abstract
We illustrate how to collect data on jet fuel and heating oil futures from the Bloomberg Terminal and compute the optimal hedge ratio for airline companies using heating oil futures to hedge jet fuel cost using OLS model and Vector Error Correction (VEC) model. Our paper can be used in an upper-division undergraduate finance class, an MBA class, or an introductory time series class.

Introduction

Companies whose profits are heavily influenced by the changes in certain commodities prices often find it important to hedge the price risk of these commodities. The airline industry provides an ideal lab for examining corporate hedging strategies because it is a common practice for airline companies to engage in jet fuel hedging. Jet fuel oil represents a major economic expense for the industry. It is the industry's second-largest expense after labor. Jet fuel prices are not only highly volatile (For example, annualized price volatility during 1992 to 2003 was about 27%), but the levels of volatility are themselves highly variable (Carter, Rogers and Simkins, 2006).

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Airline companies often use oil futures to hedge jet fuel price risk (Morrell and Swan, 2006). Hedging helps to lock in the cost of future purchases, which protects against sudden cost increases from rising fuel prices.

A real-world example may help to shed light on how airline companies hedge. The following hedging strategies and policies are excerpted from the 10k of Delta Airlines for the fiscal year ending December 31, 2016.

**Fuel Hedging Program**

We have recently managed our fuel price risk through a hedging program intended to reduce the financial impact from changes in the price of jet fuel as jet fuel prices are subject to potential volatility. We utilize different contract and commodity types in this program and frequently test their economic effectiveness against our financial targets. We closely monitor the hedge portfolio and rebalance the portfolio based on market conditions, which may result in locking in gains or losses on hedge contracts prior to their settlement dates.

*Fuel hedging activities are intended to manage the financial impact of the volatility in the price of jet fuel. The effects of rebalancing our hedge portfolio and mark-to-market adjustments may have a negative effect on our financial results.*

We have recently managed our fuel price risk through a hedging program intended to reduce the financial impact from changes in the price of jet fuel as jet fuel prices are subject to potential volatility. We utilize different contract and commodity types in this program and frequently test their economic effectiveness against our financial targets. We closely monitor the hedge portfolio and rebalance the portfolio based on market conditions, which may result in locking in gains or losses on hedge contracts prior to their settlement dates.

One problem facing jet fuel hedgers is that there are no actively traded jet fuel futures available. Therefore, jet fuel hedgers have to engage in the so called “cross hedging” that involves using futures on a similar or closely related commodity. The key to cross hedging is to find out how many futures contracts are needed to hedge a certain position in the commodity of interest. For example, airline companies hedging jet fuel positions using heating oil futures or crude oil futures need to find out the number of heating oil-crude oil futures contracts that they need to hedge their jet fuel cost. For this purpose, they would normally want to find the optimal
hedge ratio. The hedge ratio is “the ratio of the size of the position taken in futures contracts to the size of the exposure” (Hull, 2015, page 58). For an airline company engaging in jet fuel hedging using heating oil futures, the hedge ratio dictates how many gallons of heating oil is needed for each gallon of jet fuel. A general solution to the problem is to find the hedge ratio that minimizes the variance of the hedged portfolio. We use data from the Bloomberg Terminal to illustrate how to compute the optimal hedge ratio using OLS and VEC models.

**Assignments to the Students**

The example shown in the paper describes a hedging strategy that involves using heating oil futures to hedge the price risk of jet fuel. The assignments for the students are: follow the example in the paper, find the historical prices for jet fuel and light sweet crude oil and calculate the optimal hedge ratio, assuming you are using light sweet crude oil futures to hedge your position in jet fuel. Use the OLS model if you are an undergraduate student. Use the VEC model if you are a master student.

**Finding the Data in Bloomberg**

Most airline companies look forward 6 months in their hedging, with few hedges more than a year ahead and almost none beyond 2 years (Morrell and Swan, 2006). With the airline companies’ hedging horizon in mind, we use price data with weekly frequency for the period starting at October 2015 and ending at October 2016.
In order to find the needed data, we need to first type “BOIL” into the Bloomberg function bar. This will bring up the list of indexes related to crude oil. From there we go to the tab labeled “product” for assorted options on crude oil products. Next, we click on middle distillates and get the page below.

As shown, both jet fuel and heating oil appear on this page with the indexes separated by the location that the product is from. In order to have the most accurate data, it is best to use the same location for both the jet fuel and heating oil indexes. In this case, we chose New York. To get the information for the index, click once on any of the data circled above and the index will appear in the top left function bar. For us, “JETINYPR” will appear and we retype that in the function bar. Note both an index and commodity option will both appear in the search bar, but either will lead to the same place. “JETINYPR” brings us to main page for the Bloomberg New York Harbor 54-Grade Jet Fuel Sport Market Price. Typing “GP” in the search bar brings us to the historical graph for the index.
We changed our data range to capture 17 years of data with weekly frequency because this captures the full volatility of the curve. We also need the historical prices of the data in table form, which can be found with the function “HP”. This pulls up a table that can be exported to excel where we can change the range to any amount of data necessary.
We went back to 2010 for our numbers, using the weekly data. It is recommended to use at least five years for the historical pricing information, once again for being able to trace the volatility. This is all the information we need from the jet fuel index.

The second part is to find the information on Heating Oil. Initially, this requires us to follow the same steps listed at the beginning of this section to get to the first screenshot that was given. Now we will go to NY Heating Oil and clicking on the area that was circled for that gives us the security name “no2INYPR”. This brings us to Bloomberg New York Harbor No.2 Heating Oil Prompt-Month Spot Price, where we can follow the same steps that we did for JETINYPR for information on the index. We will use the function “GP” for the graph and “HP” for the historical pricing. After getting the historical pricing, once again we export that to excel with at least five years of data. Using the function GP will bring us to another chart as shown below. The chart looks similar to that of Jet Fuel but to be sure we can use the compare feature
on Bloomberg. From here click on compare and a screen will pop up asking what to compare with. Type in “JETINYPR” and then update the chart, a new graph will appear.

This is the chart that will result with heating oil being the white line and jet fuel being the yellow line. This allows us to get an easier view of the correlation.

**Methodology for Finding the Optimal Hedge Ratio**

Given that the main purpose of hedging is to reduce the volatility of a company’s cash flow, a natural solution to the problem is to find a hedge ratio that minimizes the variance of the hedged portfolio. The hedged portfolio includes a position in jet fuel and a position in oil futures. Since airline companies are jet fuel consumers who suffer from an increase in jet fuel price, they are
short in jet fuel and long in heating oil. If an airline company uses $\lambda$ units of heating oil for each unit of jet fuel, the value change in the hedged portfolio will be $\lambda \Delta F - \Delta S$. It follows that the variance of the hedged portfolio will be:

$$VAR (\lambda \Delta F - \Delta S) = \lambda^2 \sigma_F^2 + \sigma_S^2 - 2\lambda \text{COV}(F, S)$$

(1)

Take the first derivative with regard to $\lambda$, we get

$$2 \lambda \sigma_F^2 - 2 \text{COV}(F, S)$$

(2)

The optimal value of $\lambda$ is such that $2 \lambda \sigma_F^2 - 2 \text{COV}(F, S) = 0$

Therefore, $\lambda^* = \frac{\text{COV}(F, S)}{\sigma_F^2}$

(3)

The number of futures contracts needed: $N^* = \lambda^* Q_s / Q_F$

Where $Q_s$ is the size of the jet fuel position and $Q_F$ is size of one futures contract.

Some students may have noticed that the optimal hedge ratio happens to be the same as the coefficient from an OLS regression of spot price change on futures price change. We estimate the basic OLS model using the change in jet fuel price as the dependent variable and the change in heating oil futures price as the independent variable and find the following:

|                               | Coef. | Std. Err. | t     | P>|t|
|-------------------------------|-------|-----------|-------|------|
| Change in Heating Oil Futures Price | .9100 | .0219     | 41.55 | 0    |
| _cons                        | -.0109| .1830     | -0.06 | 0.9520 |

The coefficient 0.9100 is the optimal hedge ratio we are looking for, suggesting that we need 0.9100 gallons (metric tons) of heating oil for each gallon (ton) of jet fuel.
VEC Model: VEC model is used in place of OLS when the variables are cointegrated. For two variables to be cointegrated, they have to be: 1) nonstationary in levels, 2) stationary in differences, and 3) a linear combination of this collection is integrated of order zero. A stationary process is a stochastic process whose joint probability distribution does not change when shifted in time. Consequently, parameters such as mean and variance, if they are present, also do not change over time. A process is integrated of order d if taking repeated differences d times yields a stationary process. An intuitive rational for not using OLS for nonstationary series is that, if both series have a time trend, OLS will most likely find a significant relationship between the two in the absence of an economic reason why they would be related, AKA a spurious correlation.

We conduct the VEC regression in three steps.

First, we need to establish that the two series are non-stationary in levels and that they are stationary in differences. We perform the augmented Dickey-Fuller (ADF) regression to examine whether the two series are stationary in levels. For each series, the null hypothesis is that the series contains a unit root, and the alternative is that the series was generated by a stationary process. The ADF test fits a model of the form

\[ \Delta S_t = a_0 + a_1 S_{t-1} + \sum_{i=1}^{p} a_i \Delta S_{t-i} + \lambda t + \epsilon_t \]  \hspace{1em} (4)

\[ \Delta F_t = \beta_0 + \beta_1 F_{t-1} + \sum_{i=1}^{p} \beta_i \Delta F_{t-i} + \gamma t + \epsilon_t \]  \hspace{1em} (5)

Where S stands for spot (jet fuel) price and F stands for futures (heating oil) price. We can use the Dfuller command in Stata to estimate equations (4) and (5).
Stata codes:

Dfuller S, lags(5)
Dfuller F, lags(5)

We get the following results:

<table>
<thead>
<tr>
<th></th>
<th>Jet Fuel</th>
<th>Heating Oil</th>
</tr>
</thead>
<tbody>
<tr>
<td>Test Statistic</td>
<td>Z(t)</td>
<td>Z(t)</td>
</tr>
<tr>
<td></td>
<td>-0.862</td>
<td>-0.764</td>
</tr>
<tr>
<td>1% Critical value</td>
<td>-3.451</td>
<td>-3.451</td>
</tr>
<tr>
<td>5% Critical value</td>
<td>-2.876</td>
<td>-2.876</td>
</tr>
<tr>
<td>10% Critical value</td>
<td>-2.570</td>
<td>-2.570</td>
</tr>
</tbody>
</table>

MacKinnon approximate p-value for Z(t) = 0.8002

The Z-scores yielded by the test show that both jet fuel price and heating oil futures price have a unit root, because they fall within the acceptance interval (i.e. |Z| < |critical value|). Next, we test the unit root of the first difference using the following Stata codes:

Dfuller SD1, lags(5)
Dfuller FD1, lags(5)

The results are as follows:
### Interpolated Dickey-Fuller

<table>
<thead>
<tr>
<th>ΔJet Fuel</th>
<th>Test Statistic</th>
<th>1% Critical value</th>
<th>5% Critical value</th>
<th>10% Critical value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Z(t)</td>
<td>-7.096</td>
<td>-3.451</td>
<td>-2.876</td>
<td>-2.570</td>
</tr>
</tbody>
</table>

MacKinnon approximate p-value for Z(t) = 0

### Interpolated Dickey-Fuller

<table>
<thead>
<tr>
<th>ΔHeating Oil</th>
<th>Test Statistic</th>
<th>1% Critical value</th>
<th>5% Critical value</th>
<th>10% Critical value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Z(t)</td>
<td>-7.320</td>
<td>-3.451</td>
<td>-2.876</td>
<td>-2.570</td>
</tr>
</tbody>
</table>

MacKinnon approximate p-value for Z(t) = 0

The Z-scores yielded by the test show that both jet fuel price and heating oil futures price are stationary in differences.

Step 2: We can test cointegration by running a regression of one of the series on the other and testing the residuals for stationary using the ADF test where the null hypothesis is that the residuals are non-stationary. Rejecting the hypothesis leads to the conclusion that the residuals are stationary and therefore, the series are cointegrated. Presence of Cointegration is investigated by testing the presence of a unit root in the residuals of the following Cointegration regression:

\[ S_t = a + bF_t + \mu_t \] (6)

The null hypothesis of non-Cointegration is tested by applying the ADF test on the following regression:

\[ \Delta \mu_t = \delta \mu_{t-1} + \sum_{j=1}^{q} \gamma_i \Delta \mu_{t-j} + \nu_t \] (7)

where \( \nu_t \) is white noise. Critical values are obtained from MacKinnon (1991).

Stata codes:
gen mu =.
reg S F
predict ehat1, res
replace mu = ehat1
dfuller mu, lag(5)

The results are as follows:

<table>
<thead>
<tr>
<th>mu</th>
<th>Test Statistic</th>
<th>1% Critical value</th>
<th>5% Critical value</th>
<th>10% Critical value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Z(t)</td>
<td>-5.681</td>
<td>-3.451</td>
<td>-2.876</td>
<td>-2.570</td>
</tr>
</tbody>
</table>

MacKinnon approximate p-value for Z(t) = 0

Rejecting the null hypothesis leads to the conclusion that the residuals are stationary and therefore, the two series are cointegrated.

Step 3: We estimate the following vector error correction model:

\[
\Delta S_t = \alpha \mu_{t-1} + \beta \Delta F_t + \sum_{i=1}^{m} \delta_i \Delta F_{t-i} + \sum_{j=1}^{n} \theta_j \Delta S_{t-j} + e_t \quad (8)
\]

where enough lagged differences will be added to ensure \( e_t \) is white noise. Parameters of model (8) are estimated by employing the two-step procedure of Engle and Granger (Ghosh, 1993). In the first step, cointegrating residuals \( \mu_t \) are collected from (6). In the second step, equation (8) is estimated using OLS regression where lagged variables are chosen by the Akaike information criterion. The estimated coefficient \( \hat{\beta} \) is the optimal hedge ratio we are looking for. We determine the optimal number of lags using Akaike’s information criterion (AIC). The Stata codes for estimating the AIC statistics are as follows:

varsoc S F
We find the following lag-order selection statistics:

<table>
<thead>
<tr>
<th>lag</th>
<th>LL</th>
<th>LR</th>
<th>df</th>
<th>p</th>
<th>AIC</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>-3192.59</td>
<td></td>
<td></td>
<td></td>
<td>17.6986</td>
</tr>
<tr>
<td>1</td>
<td>-2217.17</td>
<td>1950.9</td>
<td>4</td>
<td>0</td>
<td>12.3167*</td>
</tr>
<tr>
<td>2</td>
<td>-2213.69</td>
<td>6.947</td>
<td>4</td>
<td>0.139</td>
<td>12.3196</td>
</tr>
<tr>
<td>3</td>
<td>-2212.35</td>
<td>2.6768</td>
<td>4</td>
<td>0.613</td>
<td>12.3344</td>
</tr>
<tr>
<td>4</td>
<td>-2205.62</td>
<td>13.476*</td>
<td>4</td>
<td>0.009</td>
<td>12.3192</td>
</tr>
</tbody>
</table>

AIC suggests that the optimal number of lags is 1. Therefore, we estimate Equation (8) setting m equal to 1. We get the following results:

<table>
<thead>
<tr>
<th></th>
<th>Coef.</th>
<th>Std. Err.</th>
<th>t</th>
<th>P&gt;t</th>
</tr>
</thead>
<tbody>
<tr>
<td>ΔFₜ</td>
<td>.9223</td>
<td>.0207</td>
<td>44.35</td>
<td>0</td>
</tr>
<tr>
<td>μₜ₋₁</td>
<td>-.1405</td>
<td>.0513</td>
<td>-2.74</td>
<td>0.007</td>
</tr>
<tr>
<td>ΔFₜ₋₁</td>
<td>.0883</td>
<td>.0519</td>
<td>1.70</td>
<td>0.090</td>
</tr>
<tr>
<td>ΔSₜ₋₁</td>
<td>-.0862</td>
<td>.0514</td>
<td>-1.68</td>
<td>0.094</td>
</tr>
<tr>
<td>_cons</td>
<td>.1723</td>
<td>.6415</td>
<td>0.27</td>
<td>0.788</td>
</tr>
</tbody>
</table>

The coefficient of ΔFₜ is the optimal hedging ratio, which turns out to be 0.9223. The result suggests that we need 0.9223 units of heating oil for each unit of jet fuel.
Reference


