A. Introduction

Industrial organizations purchase their energy requirements in several forms. Oil, coal, natural gas and electricity are the most widely used sources of purchased energy. All of these energy sources have shown price increases in the past few years. The industrial grade fuel oil (number 6 residual fuel) has risen to $24.50 a barrel in July 1981 from $16.00 a barrel in July 1979. This represents an annualized increase of about 28%. Although oil prices have stabilized in the past year increases of this magnitude are still possible. In those industries where energy constitute a large portion of the manufacturing costs financial performance and market position of the company could be adversely affected by sharply rising energy costs. Companies have instituted programs to alleviate the rising cost of energy. Some of those programs are:

1. conservation
2. boiler conversion to multiple use fuels to take advantage of the currently lowest price fuel
3. long-term energy contracts (when available)
4. hedging future fuel requirements

This paper discusses the application of the SAS ARIMA procedure to forecast oil prices for the purpose of hedging future fuel requirements.

B. Description of the Hedging process

1. Background

The discussion of commodity hedging will be limited here to a buying hedge and to long positions in the market.

Understanding the hedging process requires an understanding of the commodity futures contract. A futures contract is simply an agreement to take delivery of a specified amount of a commodity, of a specified quality grade, during a specific month in the future. The unit price is established at the time the buyer purchases the contract. For example, a large candy manufacturer would have constant requirements for cocoa and sugar. Rather than purchase these commodities at an uncertain price in the market each time there are requirements to replenish raw material inventories, the manufacturer may choose to purchase a futures contract for delivery about the time when the material is needed.

2. Hedging

The commonly accepted definition of hedging is: "Hedging is taking a position in a futures market that is intended as a temporary substitute for the purchase of the actual commodity, i.e., purchasing a futures contract in anticipation of future purchases of the commodity as a protection against possible increasing prices." Hedging is necessary when there is insufficient storage capacity to take advantage of low prices, or the cost of capital invested becomes excessive.

For example, if in January the candy manufacturer knows that 1,120,000 pounds of sugar is required in July and a price increase is anticipated, the manufacturer could purchase in January a contract of July sugar. The price per pound for the July delivery is determined in January at the time of the purchase of the futures contract. The price per pound for the futures contract is determined by what buyers and sellers in the market place believe the demand and supply situation will be in July. Weather, labor strikes and national politics of the supplying countries can all affect the supply and thus the unit price of the commodity. If the price of sugar does rise in the cash market, the prices of sugar futures will also rise. Since the candy manufacturer has purchased a futures contract for delivery at a price per pound less than the current cash market price he can either take delivery of the contract or sell the contract, take his profit, then purchase the sugar in the cash market. In both cases the net price per pound to the manufacturer will be less than the current prevailing market price (July price).

Obviously, if the cash price of the commodity fails below the futures contract price at the time of delivery, the manufacturer could be in a competitively disadvantaged position due to the need to buy raw material at prices above the current cash price.

In order that the buying hedge work successfully under the particular conditions imposed here, the following must occur:

1. there must be a future requirement for a commodity
2. cash price at the time of delivery must be higher than the price for the futures contract

The decision to hedge thus depends directly on being able to correctly forecast commodity prices. If an accurate forecast can be provided which shows declining commodity prices at the date when delivery is required, the manufacturer will not hedge. Instead, he can buy in the cash market at the time of the required delivery. If the commodity cash price is forecasted to be higher than the current market price for future delivery, a hedge may be considered.

3. Special Conditions for Oil Commodities

Oil is not a single commodity, but a variety of grades and types. The oil which is used by industrial firms for energy is known as Number 6 fuel oil (No. 6 oil). This commodity, however, is not traded on any exchange and therefore applying a hedge directly to No. 6 oil is not possible. Another commodity, Number 2 fuel oil (No. 2 oil) which is not usually used as fuel by energy users due to its high price, is traded on the commodity exchange. No. 2 oil also is used for residential heating and diesel. No. 2 oil is subject to cyclic price variations as demand for the commodity rises in the winter months. The cyclic price variations and the probable high price correlation to No. 6 oil
makes No. 2 oil an excellent candidate to act as a surrogate for hedging No. 6 oil. The hedging operation for No. 6 oil would work as follows:

1. Identify a future requirement for No. 6 oil.
2. Forecast prices for No. 2 oil.
3. If there is a forecast for rising prices for No. 2 fuel oil, purchase a No. 2 fuel oil futures contract due approximately when the No. 6 oil is to be purchased.
4. About the time of the No. 6 oil purchase requirement, sell the No. 2 futures contracts taking the profits accrued from the rising prices.
5. Purchase the No. 6 oil requirement at the prevailing cash price and apply the gain from the sale of the No. 2 futures contracts to offset the rising No. 6 oil prices.

The following is an illustrative example (see Chart 1):

Assume that in July it is determined there is a 420,000 gallon (1,000 gal./barrel) requirement for No. 6 oil due in early December which is five months away. No. 6 oil is currently selling for $0.47 per gallon, however, a forecast for December indicates a price rise to $0.80 per gallon. The forecast also indicates that No. 2 oil will be selling around $0.95 per gallon by December. A 42,000 gallon December futures contract for No. 2 oil can be currently purchased for $0.85 per gallon. The conditions are right for a hedge on No. 2 fuel oil. If five futures contracts (at 42,000 gallons each) of December No. 2 fuel oil are purchased, and if the forecast is correct the following will occur:

1. The No. 2 oil futures contracts will be sold in late November at or near the $0.95 per gallon price. The gain from this sale will be (42,000 x 5) x (.95 - .85) = $21,000
2. Purchase 420,000 barrels of No. 6 oil at $0.85 per gallon and apply the gain from the sale of the No. 2 oil futures to offset the price increases of No. 6 oil since July. (420,000 gallons x .80) - $21,000 = $315,000. This sets the net price per gallon for No. 6 oil at $0.75, which would be $0.05 per gallon less than the late November cash price.

A savings of $0.05 may seem to be a small amount but when an industrial firm purchases from large quantities of No. 6 oil per year, the savings can be substantial indeed.

C. Analyzing Conditions for a Hedge

The conditions for hedging No. 6 oil by using No. 2 oil as a surrogate must be carefully analyzed before deciding to buy future contracts. The principal component to be analyzed is the forecasted price of No. 2 oil futures and the cash price of No. 6 oil. All of the possible outcomes between the prices of No. 2 oil and No. 6 oil are shown in Figure A.

After examining all the possible outcomes of the price forecasts between No. 2 oil futures and No. 6 oil, it becomes obvious that the only time in which a hedge can be successfully accomplished is when the price forecast for No. 2 oil futures is increasing. This is for a firm exhibiting prudence, and avoiding speculative hedging. The number of possible outcomes is therefore reduced to the three possibilities shown in the Figure A (1, 4, 7).

D. Forecasting No. 2 Futures and No. 6 Oil Prices

The key to making hedging decisions can be seen to rely on the ability to forecast the No. 2 oil futures and the No. 6 oil cash prices. Only the outcome '1' shown in the chart of figure A will be considered.

The forecasts for prices were accomplished by first collecting historical data of the average weekly closing prices for No. 2 oil and No. 6 oil cash prices and using the ARIMA procedure within SAS to model and forecast the prices of these two time series. The historical plot of these two prices are shown in chart 2. The forecasting problem is made difficult because of the high volatility (non-linearity) of the price over time. A regression forecasting model is not feasible since regression analysis is predicated upon the existence of a set of explanatory variables. The identification of a set of independent variables which can explain oil price fluctuations is not possible because of the complexity of the phenomenon and its relationship to non-quantifiable factors (political, psychological, etc.).

The identification phase of the model analysis is based on Table 1.

After completing the identify and estimate phases an ARIMA (2,0,1) model with a period of 52 was used to forecast both No. 2 oil and No. 6 oil prices. That is, the model uses a 52 week seasoned period with first order seasonal differencing. There is a second order autoregressive component and a first order moving average component. A plot of the historical price data and the forecast of each oil can be seen in charts 3 and 4. The futures prices of No. 2 oil obtained from the New York mercantile exchange on January 28, 1982 were overlayed on Chart 3. These prices are shown as asterisks. The futures prices are an indicator of the market price of No. 2 oil since they represent what buyers are willing to pay for future delivery. The futures price and the No. 2 oil spot price will converge on the delivery date. It can be seen from the plot that the model has almost matched what traders in the futures market believe is going to happen.

Since our forecast for both oils is downward, a hedging operation is not recommended. No profits can be gained by taking long positions in No. 2 oil and there is no need to hedge No. 6 oil since the price is falling and should remain depressed for about 6 months. The decision to hedge or not to hedge is clearly not to hedge at this time. Futures contracts which are currently being held which have delivery prices higher than the forecasted No. 2 oil prices should be liquidated.

Note: Cash prices for No. 2 oil and No. 6 oil on February 12, 1982 were: No. 2 = $0.8800; No. 6 = $0.9800;
CHART 1

OIL PRICES
JANUARY, 1981 CONTRACT

LEGEND: PRICE —— CASH NO.2 —— CASH NO.6 —— FUTURE
<table>
<thead>
<tr>
<th>Action</th>
<th>Hedge</th>
<th>Do Not Hedge</th>
<th>Do Not Hedge</th>
<th>Possible Hedge</th>
<th>Do Not Hedge</th>
<th>Do Not Hedge</th>
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<th>Do Not Hedge</th>
<th>Do Not Hedge</th>
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<tbody>
<tr>
<td>Result</td>
<td>Gain</td>
<td>Increase In No. 6 Oil costs</td>
<td>Increase In No. 6 Oil costs</td>
<td>Speculative Gain</td>
<td>No Change</td>
<td>Speculative Gain</td>
<td>Gain from Reduced No. 6 Oil Prices</td>
<td>Gain from Reduced No. 6 Oil Prices</td>
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**Possible Outcomes For No. 2 Oil And No. 6 Oil Prices**

<table>
<thead>
<tr>
<th>1</th>
<th>2</th>
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<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
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<tr>
<td>No. 2 Oil Futures Price</td>
<td>Increase</td>
<td>Stable</td>
<td>Decrease</td>
<td>Increase</td>
<td>Stable</td>
<td>Decrease</td>
<td>Increase</td>
<td>Stable</td>
</tr>
<tr>
<td>No. 6 Oil Futures Price</td>
<td>Increase</td>
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<td>Stable</td>
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<td>Stable</td>
<td>Decrease</td>
<td>Decrease</td>
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</tbody>
</table>

**Action And Result For Each Outcome**

Figure A.
CHART 2

AVERAGE WEEKLY OIL PRICES
NO. 2 AND NO. 6 OIL CASH PRICES

MONTH-YEAR

LEGEND: PRICE —— NO. 2 OIL —— NO. 6 OIL
CHART 4

NO.6 OIL FORECAST

CASH PRICE

MONTH-YEAR

1981 1982

CONFIDENCE LIMITS

FORECAST
No. 6 = $0.5714 per gallon, following closely the forecast produced on January 28, 1982.

E. Analysis of the Basis

In an attempt to determine if the prices of No. 2 and No. 6 oil always moved apart or together during particular times of the year a plot was made of the difference between No. 2 oil and No. 6 oil. This difference was plotted on the same one year axis. The results are shown in Chart 5. The conclusion is that the two oil prices have not moved together the same way in the past three years. The large spike in the year 1979 is the result of the market perceiving instability in the Middle-East.

<table>
<thead>
<tr>
<th>Sample Autocorrelation</th>
<th>AR (p)</th>
<th>MA (q)</th>
<th>ARIMA (p, q)</th>
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<tbody>
<tr>
<td></td>
<td>Damped exponential and/or damped sine wave</td>
<td>Cuts off at lag q</td>
<td>Damped exponential and/or damped sine wave</td>
</tr>
<tr>
<td>Sample Partial Autocorrelation</td>
<td>Cuts off at lag p</td>
<td>Damped exponential and/or damped sine wave</td>
<td>Damped exponential and/or damped sine wave dominates after lag p - q</td>
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</table>
CHART 5

THREE YEAR PLOT OF THE BASIS BETWEEN NO.2 OIL & NO.6 OIL