The Problem:
You run an oil storage facility which is connected to a refinery. Your facility has a storage capacity of 1 million barrels.

The refinery requires 10,000 bpd to operate which you remove from your storage containers at the end of each day. If you cannot fulfill this need, the refinery will have to do an emergency shut down with catastrophic consequences. You receive oil_spot for each barrel that you sell to the refinery.

You are able to purchase up to 30,000 bpd from a pipeline located near your facility at the price given in series oil_spot. The oil is added to your storage container throughout the day. In addition to the 30,000 bpd available at oil_spot, you can buy up to 30,000 bpd more from the pipeline at a cost of oil_spot x 1.01.

You are allowed to sell up to 30,000 bpd back to the pipeline provider for the price of oil_spot x 0.99.

You are allowed to buy and sell oil in units of one barrel.

On a specified start date, you will be given the storage facility with 500,000 barrels of oil, no cash, and no futures exposure. Prior to the start date, you cannot do any transactions. You can invest your cash holdings at the overnight deposit interest rate of 0.008%. You may borrow at the overnight borrowing interest rate of 0.001%.

If your debt ever exceeds 50% of the value of your oil holdings, you must sell up to 30,000 bpd to the pipeline until your debt is below 50% of the value of your oil holdings. The value of your oil holdings is calculated as the current amount of oil in your storage facility times the current oil_spot price.

The refinery, pipeline, and markets are open only on the days listed in the data file. As well, you do not generate or pay interest on dates not in the file.

You may buy and sell futures for hedging purposes. The minimum trading increment is 1 barrel. The prices for the futures contracts are given in the series oil_futures. There is a cost of 0.05% times oil_futures to trade a futures contract on a barrel of oil. No margin needs to be posted, so aside from the transaction cost, there is no cash transfer when you buy or sell the contracts. The profits and losses on your futures contract positions are added to your cash account each night.

The contracts mature in December, but you will never take physical delivery of your futures contracts. Instead you will roll them to the next year's contract at the beginning of August each year. This roll procedure is done for you automatically by the exchange at no cost, and your futures profit and loss calculation on the date of the roll incorporates an adjustment for the difference between the next year's contract price and this year's contract price. This adjustment is given by oil_futures_rs. For example, if the futures for

delivery in 2018 is priced at $55 and the futures for delivery in 2019 is priced at $60, the market indicates it expects the price of crude to rise $5 between 2018 and 2019 and this spread would be the oil_futures_rs on the date of the roll.

The profit-and-losses (p&l) calculation is calculated as: oil_futures(t+1) – oil_futures(t) – oil_futures_rs (t+1) per contract. If one held a single contract on 20020801, the overnight p&l credited to your account at the end of the day on 20020802 would be 24.013 – 25.714 + 1.961 = 0.26

date	oil_spot	oil_futures	oil_futures_rs
20020801	26.47	25.714	0
20020802	26.82	24.013	-1.961
20020805	26.57	23.89	0

When you predict the oil_futures price, realize that oil_futures_rs applied to oil_futures on t+1 is known to you at date t.

Since you are purchasing futures for hedging purposes, your net exposure to oil as measured in futures contract + your inventory must be between 0 and 1 million barrels.

Your task is to determine how much oil to buy from or sell to the pipeline each day and how many futures contracts you wish to buy and sell. Your solution should be implementable in real time and so be free of look-ahead bias.

Your objective is to maximize the real-time Sharpe ratio defined below. Our evaluation will be based on what we think the realized Sharpe ratio of your strategy will be in years to come.

Timing of variables:
The spreadsheet you have been provided contains daily end-of-day price data. Each day you observe these prices, you forecast tomorrow's end-of-day oil_spot and oil_futures price, and you decide what to buy and/or sell now at the prevailing prices at the end of the day today. Your decision rule should be written as an explicit function of information available at the time the decisions were made. Your positions are held fixed until the end of the next trading day at which time the new set of prices are available and you decide on a new set of buys and sells, and you compute your daily profit-and-losses.

Overnight procedure:
At the end of each day, using the oil_spot and oil_futures from that day, the following events occur in your accounts in the order given below

1) Interest based on the amount of funds in your cash account as of the previous day is paid or received.
2) Futures profit-and-loss is calculated and credited to your cash account
3) Oil is bought or sold to the pipeline
4) 10,000 barrels of oil are transferred to the refinery at price of oil_spot

5) Futures transactions are executed
6) Debt to oil holdings are calculated. If necessary, oil holdings are sold until you have sold 30,000 bpd to the pipeline or your debt to oil holdings ratio is 50% or less.
7) Net oil exposure between 0 to 1 million barrels is confirmed

Sharpe ratio:
The Sharpe ratio should be computed as the average daily profit-and-loss divided by the sample standard deviation of the daily profit-and-loss.

Start date:
For the in-sample period, you will be given the storage facility on Jan 3, 2005 prior to the Overnight Procedure described above.

Data set:
Please see the appropriate data.csv for oil_spot, oil_futures, and oil_futures_rs series. Other unspecified contracts are included with correspondent names "cxxx" and "cxxx_rs". The futures contracts represented are:

c0	Copper
c1	Heating Oil
c2	Natural Gas
c3	Canadian Dollar
c4	Australian Dollar
c5	DAX
c6	Lumber
c7	Cattle
c8	10Yr US Note
c9	Gasoline

You are allowed to incorporate any free and publicly available data into your analysis. These variables must be included in your solution and their source must be documented. Note that the databases available on campus which require a paid subscription are not considered publicly available even if the university is paying the subscription.

Baseline strategy:
You must include in your answers the following baseline strategy.

Each day beginning on the start date, rounding up to the nearest barrel,
1) sell to the pipeline 1% of your start-of-day oil holdings; and
2) buy 10,000 barrels from the pipeline, offsetting your sales in step 1); then
3) partly hedge your position by buying 1/2 barrel in the futures market for every barrel you sell in step 1); and
4) sell 10,000 barrels to the refinery as required.

Deliverables:
By 2pm on Sunday, you must submit your time series results (described below) for the in-sample data set. At this point, your model will be set and cannot be changed.

At 2pm on Sunday, a data set will be emailed to you including data from 2011 to the present. You will apply your model to this data set.

At 5pm on Sunday each team must email to Erin Provost [erinp@wil.com] 2 additional time series files with the output described below as well as a PDF file.

Any submissions or revisions after these deadlines will not be considered.

The csv files are files with comma separated values which you can create in a spreadsheet application, or using any other application you wish.

Your csv files should contain a single header row. The number of rows in your file should be equal to the number of rows in the file in_sample_data.csv or out_sample_data.csv files. Each file should have the following columns in the following order.:

1) Date, formatted in yyyymmdd
2) Barrels bought or sold to pipeline
3) Futures contracts bought or sold (in barrels)
4) Barrels of oil in tank at the end of the overnight procedure
5) Cash account value at the end of the overnight procedure
6) Futures contracts held at the end of the overnight procedure (in barrels)
7) Debt value divided by the market value of oil holdings
8) Daily profit and loss
9) One-day-ahead oil_spot forecast
10) One-day-ahead oil_futures forecast

A separate csv file should be provided to include any additional variables which you used.

The PDF file must contain time series plots of the series in the csv files you will send to Erin. It must also contain the details of and motivation for the decision rule used for buying and selling spot and futures oil each day. Please explain any coefficients that you use. Should your team be chosen for presentation then you will do a 7-10 minute presentation followed by a question and answer session. All judges will be given the PDF document and no further handouts are allowed.

The PDF file should also include the R^2 forecasting performance for your spot and futures price forecast from the start date forward. Report R^2 as one minus the ratio of sum

of squared forecast error for your optimal forecast divided by the sum of squared forecast error for the random walk forecast. The random walk forecasts are

oil_spot(t+1) ~ oil_spot(t), and
oil_futures(t+1) ~ oil_futures(t) + oil_futures_rs(t+1).

Please report the R^2 for your spot price forecast and also for your futures price forecast.

Summary of Deliverables:
By 2PM Sunday March 15:

CSV files:	baseline_in_sample.team_###.csv
	strategy_in_sample.team_###.csv
	additional_data_in_sample.team_###.csv

2PM Sunday March 15:
Additional data will be emailed.

By 5PM Sunday March 15:

CSV files:	baseline_out_sample.team_###.csv
	strategy_out_sample.team_###.csv
	additional_data_out_sample.team_###.csv
PDF file:	model.team_###.pdf

Questions can be emailed to erinp@wil.com by **2PM on Saturday March 14th. Based upon the questions received, we will address select questions and concerns, and email one response to all teams Saturday evening. All questions will be kept anonymous.**