Midterm Exam
Derivatives and Financial Engineering
Professor Craig Pirrong
Fall, 2005

Directions: Answer all questions as completely and concisely as possible. Partial credit will be granted based on the correctness and completeness of your answer, so show your work; no credit will be given for answers lacking supporting calculations or explanations. I deduct points for extraneous material, so keep your answers succinct and to the point. This exam is an individual take home exam, and it is expected that you not discuss it with anyone (Prof. Pirrong excepted), and that includes your fellow ERM members. Moreover, you should complete the exam in less than 3.5 hours at a single sitting. ***Good Luck!***

Part I. **Short Answer**.

1. The initial margin for NYMEX Natural Gas futures (front month) is $21,600 for a non-member customer. The maintenance margin level is $16,000. You are short one NYMEX NG futures contract, and begin the day with $17,500 in your margin account. Today the NYMEX NG futures settles $.25 (25 cents) higher than yesterday's settlement. Will you have to pay money into your margin account, or will money be put into your margin account? How much money will go into/out of your account? (5 points)

You lose $.25/MMBTU x 10K MMBTU=$2500.00. This reduces your margin balance to $15K, so you need to inject $6600 to bring your margin balance back up to the original margin level.

2. Speculators in energy markets have been blamed for recent volatility in gas and oil prices. Consider the following scenario: In response to this criticism of speculators, regulators impose restrictions on them that make it costlier for them to participate in the energy markets. Immediately prior to the effect of the new regulations, in the oil derivatives market, hedgers are net long. At this time, hedgers in the gas derivatives market are net short. Assuming nothing else changes, predict the effect of the new regulations on the trend (drift) in oil futures prices and the trend (drift) in gas futures prices. Briefly describe how these changes in the trends will impact the cost of hedging in the oil and gas markets. Explain your reasoning. (10 points)

Speculators absorb hedging imbalances and thereby reduce (and perhaps eliminate) pricing biases. Making it costlier for speculators to participate in the market will make biases worse. Since hedgers are net long in oil, the price bias should already be positive and get larger. Thus, the downward trend in crude futures prices should become more pronounced. Similarly, in gas, since hedgers are net short, the price bias is negative, and should get bigger (in absolute value) meaning a more pronounced upward trend.

3. Industrial commodity prices—not just energy, but things like copper too—have been booming over the past year. In large part this has been driven by robust demand from China. China's banking system is somewhat shaky, and a disruption in Chinese financial markets would likely lead to a substantial decline in the country's growth. Describe the likely impact of a disruption in the Chinese banking system on: (a) inventories of industrial commodities; (b) the shape of industrial commodity forward curves (i.e., will these curves become more or less backwardated); (c) the volatility of industrial commodity spot and forward prices; (d) the difference in the volatility between spot and forward prices; and (e) the correlation between spot and forward prices for a given industrial commodity. Concisely explain your reasoning. (10 points)

A collapse in the Chinese banking system should reduce the country's rate of growth, leading to a reduction in worldwide demand for commodities. When demand is low (the supply-demand balance is "slack") it is optimal to accumulate inventories for use when demand rebounds. Increased inventories are associated with a move from backwardation to contango (and perhaps full carry)—this is to increase the rewards to storage. Lower backwardation/bigger contango (more economic slack) implies (a) lower volatility, (b) a smaller difference between spot and forward vols, and (c) a higher correlation between spot and futures.

4. True, false, or uncertain: The entry of new generating capacity in a power market will cause an increase in the upward bias in power forward prices in that market. Explain your reasoning. (5 points)

Power forward prices are upward biased due to "spikeaphobia:" if you are short power forwards, you can get really whacked if prices spike. Therefore, the smaller the likelihood of spikes, the smaller the upward bias. Entry of new capacity shifts out the supply curve, and holding demand constant, this means a lower likelihood of a price spike (we have more capacity to absorb demand fluctuations). Fewer price spikes mean less upward bias. Therefore, FALSE.

5. True, false, or uncertain: Because NYMEX futures contracts are guaranteed by the NYMEX clearinghouse, if the brokerage firm that I use to trade NYMEX futures goes bankrupt I will face no risk of loss. Explain your reasoning. (5 points)

No. The clearinghouse only guarantees net positions from its clearing members. There are scenarios (which have played out in reality) in which customers of a clearing firm have lost money. (Hopefully, this won't happen in the burgeoning REFCO scandal.) Therefore, FALSE.

6. The price of gold spot is $471.3 per ounce. The gold forward price for delivery in 2 months is $475.4. The interest rate (continuously compounded, annualized) is 4 percent per year. Identify an arbitrage opportunity. Specify the trades you would implement to exploit it (What would you buy? What would you sell? Would you borrow of lend cash?) How much money will you make if you trade 10,000 ounces of gold? (10 points)

Exp(.04*2/12)*471.3=474.45. Therefore, futures are rich, spot is cheap. Sell futures, buy spot, borrow to finance. At expiration, you make 10000*(475.4-474.45)=$9500. In present value, this works out to about $9400.

Part II. Valuation Problem.

Today you observe the following data:

Delivery Month	NYMEX NG	Chicago City Gate	Discount Factor
200601	15	15.75	0.986842
200602	14.75	15.375	0.983564
200603	14.4	15	0.980296
200604	11.4	11.9	0.977039
200605	10.98	11.5	0.973793
200606	10.98	11.5	0.970558
200607	10.88	11.53	0.967333
200608	10.9	11.5	0.96412
200609	10.9	11.43	0.960917
200610	10.9	11.38	0.957724
200611	11.35	11.96	0.954542
200612	11.75	12.45	0.951371

The first column is the delivery month (200601 meaning January, 2006, etc.); the second column is a forward price for delivery at the Henry Hub; the third column is the forward price for delivery at the Chicago City Gate; the last column is a discount factor. Assume you can trade forwards for each of the delivery months at each of the locations at the prices quoted above.

You contact a market maker who is currently quoting a calendar 2006 basis swap (NYMEX NG – Chicago City Gate) at a bid of -.70 and an offer of -.68. Each month January 06-December 06 this swap pays the difference between the NYMEX Natural Gas futures last day settlement price and the Chicago City Gate monthly NGI index price, minus the fixed price. (When subtracting, you need to keep the negative sign on the fixed price into account!) For instance, if you buy the swap, the January NG futures settles at $17.00, the Chicago index is $18.00, your cash flow is 17-18-(-.68)=-.32/MMBTU. If you sold the swap, your cash flow is -17+18+(-.7)=+.30/MMBTU.

The Chicago City Gate forwards for which prices are quoted above pay the difference between the NGI index price and the forward price (for a forward purchase—the reverse for a forward sale).

Identify an arbitrage opportunity. To exploit this opportunity, should you buy the basis swap from the market maker, or sell it to him? To execute the arbitrage, what should you do in the NYMEX NG futures market (buy or sell?) What should you do in the Chicago City Gate forward market (buy or sell?). If you trade 30,000 MMBTU/month, how much money will you make at the market maker's expense? Show your work. (35 points)

There are many ways to handle this problem. One is to use the relevant futures prices to calculate the fixed price for a NYMEX cal 06 swap and a CCG cal 06 swap using the formulae we used in HW1 and HW1a. The fixed price of HH is 12.029. The fixed price for CCG is 12.619. This implies a basis of 12.029-12.619=-.59. This differs from the basis quoted by the MM. If you trade with the market maker so that you receive HH, pay CCG, and receive a payment of $.68 from the market maker (you receive the payment because the basis is negative), you can hedge this by selling the HH futures and buying the CCG futures. This locks in a cash flow of .68-.59=.09 cents (don't worry about the rounding) every month. You discount each of these cash flows back and multiply by 30,000 and you get a total profit of $31,200. If you trade with the market maker so that you pay HH, receive Chicago, and pay $.7 to him, you can hedge this by buying HH forward, selling CCG forward. This generates a cash flow of .59-.7=-.11 per month (that's a negative 11 cents). Discounting, multiplying by quantity and adding across months implies a PV of -$38177.65 (again, a negative number). So, you should receive HH pay CCG and receive .68 from the market maker, and hedge by selling HH forward and buying CCG forward.

My webpage has a spreadsheet indicating various ways of solving the problem.