CHAPTER 2
Futures Markets and Central Counterparties

Practice Questions

Problem 2.1.
Distinguish between the terms open interest and trading volume.

The *open interest* of a futures contract at a particular time is the total number of long positions outstanding. (Equivalently, it is the total number of short positions outstanding.) The *trading volume* during a certain period of time is the number of contracts traded during this period**.**

Problem 2.2.
What is the difference between a local and a futures commission merchant?

A *futures commission merchant* trades on behalf of a client and charges a commission. A *local* trades on his or her own behalf.

Problem 2.3.
Suppose that you enter into a short futures contract to sell July silver for $17.20 per ounce. The size of the contract is 5,000 ounces. The initial margin is $4,000, and the maintenance margin is $3,000. What change in the futures price will lead to a margin call? What happens if you do not meet the margin call?

There will be a margin call when $1,000 has been lost from the margin account. This will occur when the price of silver increases by 1,000/5,000 = $0.20. The price of silver must therefore rise to $17.40 per ounce for there to be a margin call. If the margin call is not met, your broker closes out your position.

Problem 2.4.
Suppose that in September 2018 a company takes a long position in a contract on May 2019 crude oil futures. It closes out its position in March 2019. The futures price (per barrel) is $48.30 when it enters into the contract, $50.50 when it closes out its position, and $49.10 at the end of December 2018. One contract is for the delivery of 1,000 barrels. What is the company's total profit? When is it realized? How is it taxed if it is (a) a hedger and (b) a speculator? Assume that the company has a December 31 year-end.

The total profit is ($50.50 − $48.30) × 1,000 = $2,200. Of this ($49.10 − $48.30) × 1,000 or $800 is realized on a day-by-day basis between September 2018 and December 31, 2018. A further ($50.50 − $49.10) × 1,000 or $1,400 is realized on a day-by-day basis between January

1, 2019, and March 2019. A hedger would be taxed on the whole profit of $2,200 in 2019. A speculator would be taxed on $800 in 2018 and $1,400 in 2019.

Problem 2.5.
What does a stop order to sell at $2 mean? When might it be used? What does a limit order to sell at $2 mean? When might it be used?

A *stop order* to sell at $2 is an order to sell at the best available price once a price of $2 or less is reached. It could be used to limit the losses from an existing long position. A *limit order* to sell at $2 is an order to sell at a price of $2 or more. It could be used to instruct a broker that a short position should be taken, providing it can be done at a price at least as favorable as $2.

Problem 2.6.
What is the difference between the operation of the margin accounts administered by a clearing house and those administered by a broker?

The margin account administered by the clearing house is marked to market daily, and the clearing house member is required to bring the account back up to the prescribed level daily. The margin account administered by the broker is also marked to market daily. However, the account does not have to be brought up to the initial margin level on a daily basis. It has to be brought up to the initial margin level when the balance in the account falls below the maintenance margin level. The maintenance margin is usually about 75% of the initial margin.

Problem 2.7.
What differences exist in the way prices are quoted in the foreign exchange futures market, the foreign exchange spot market, and the foreign exchange forward market?

In futures markets, prices are quoted as the number of U.S. dollars per unit of foreign currency. Spot and forward rates are quoted in this way for the British pound, euro, Australian dollar, and New Zealand dollar. For other major currencies, spot and forward rates are quoted as the number of units of foreign currency per U.S. dollar.

Problem 2.8.
The party with a short position in a futures contract sometimes has options as to the precise asset that will be delivered, where delivery will take place, when delivery will take place, and so on. Do these options increase or decrease the futures price? Explain your reasoning.

These options make the contract less attractive to the party with the long position and more attractive to the party with the short position. They therefore tend to reduce the futures price.

Problem 2.9.
What are the most important aspects of the design of a new futures contract?

The most important aspects of the design of a new futures contract are the specification of the underlying asset, the size of the contract, the delivery arrangements, and the delivery months.

Problem 2.10.
Explain how margin accounts protect futures traders against the possibility of default.

Margin is money deposited by a trader with his or her broker. It acts as a guarantee that the trader can cover any losses on the futures contract. The balance in the margin account is adjusted daily to reflect gains and losses on the futures contract. If losses lead to the balance in the margin account falling below a certain level, the trader is required to deposit a further margin. This system makes it unlikely that the trader will default. A similar system of margin accounts makes it unlikely that the trader's broker will default on the contract it has with the clearing house member and unlikely that the clearing house member will default with the clearing house.

Problem 2.11.
A trader buys two July futures contracts on frozen orange juice concentrate. Each contract is for the delivery of 15,000 pounds. The current futures price is 160 cents per pound, the initial margin is $6,000 per contract, and the maintenance margin is $4,500 per contract. What price change would lead to a margin call? Under what circumstances could $2,000 be withdrawn from the margin account?

There is a margin call if more than $1,500 is lost on one contract. This happens if the futures price of frozen orange juice falls by more than 10 cents to below 150 cents per pound. $2,000 can be withdrawn from the margin account if there is a gain on one contract of $1,000. This will happen if the futures price rises by 6.67 cents to 166.67 cents per pound.

Problem 2.12.
Show that, if the futures price of a commodity is greater than the spot price during the delivery period, then there is an arbitrage opportunity. Does an arbitrage opportunity exist if the futures price is less than the spot price? Explain your answer.

If the futures price is greater than the spot price during the delivery period, an arbitrageur buys the asset, shorts a futures contract, and makes delivery for an immediate profit. If the futures price is less than the spot price during the delivery period, there is no similar perfect arbitrage strategy. An arbitrageur can take a long futures position but cannot force immediate delivery of the asset. The decision on when delivery will be made is made by the party with the short position. Nevertheless companies interested in acquiring the asset may find it attractive to enter

into a long futures contract and wait for delivery to be made.

Problem 2.13.
Explain the difference between a market-if-touched order and a stop order.

A market-if-touched order is executed at the best available price after a trade occurs at a specified price or at a price more favorable than the specified price. A stop order is executed at the best available price after there is a bid or offer at the specified price or at a price less favorable than the specified price.

Problem 2.14.
Explain what a stop-limit order to sell at 20.30 with a limit of 20.10 means.

A stop-limit order to sell at 20.30 with a limit of 20.10 means that as soon as there is a bid at 20.30 the contract should be sold providing this can be done at 20.10 or a higher price.

Problem 2.15.
At the end of one day a clearing house member is long 100 contracts, and the settlement price is $50,000 per contract. The original margin is $2,000 per contract. On the following day the member becomes responsible for clearing an additional 20 long contracts, entered into at a price of $51,000 per contract. The settlement price at the end of this day is $50,200. How much does the member have to add to its margin account with the exchange clearing house?

The clearing house member is required to provide $20 \times \$2,000 = \$40,000$ as initial margin for the new contracts. There is a gain of $(50{,}200 - 50{,}000) \times 100 = \$20{,}000$ on the existing contracts. There is also a loss of $(51,000 - 50,200) \times 20 = \$16,000$ on the new contracts. The member must therefore add

$$40,000 - 20,000 + 16,000 = \$36,000$$

to the margin account.

Problem 2.16.
Explain why collateral requirements will increase in the OTC market as a result of new regulations introduced since the 2008 credit crisis.

Regulations require most standard OTC transactions entered into between financial institutions to be cleared by CCPs. These have initial and variation margin requirements similar to exchanges. There is also a requirement that initial and variation margin be provided for most bilaterally cleared OTC transactions between financial institutions.

As more transactions go through CCPs there will more netting. (Transactions with counterparty A can be netted against transactions with counterparty B providing both are cleared through the same CCP.) This will tend to offset the increase in collateral somewhat. However, it is expected that on balance there will be collateral increases.

Problem 2.17.
The forward price on the Swiss franc for delivery in 45 days is quoted as 1.1000. The futures price for a contract that will be delivered in 45 days is 0.9000. Explain these two quotes. Which is more favorable for a trader wanting to sell Swiss francs?

The 1.1000 forward quote is the number of Swiss francs per dollar. The 0.9000 futures quote is the number of dollars per Swiss franc. When quoted in the same way as the futures price the forward price is $1/1.1000 = 0.9091$. The Swiss franc is therefore more valuable in the forward market than in the futures market. The forward market is therefore more attractive for a trader wanting to sell Swiss francs.

Problem 2.18.
Suppose you call your broker and issue instructions to sell one July hogs contract. Describe what happens.

Live hog futures are traded by the CME Group. The broker will request some initial margin. The order will be relayed by telephone to your broker's trading desk on the floor of the exchange (or to the trading desk of another broker). It will then be sent by messenger to a commission broker who will execute the trade according to your instructions. Confirmation of the trade eventually reaches you. If there are adverse movements in the futures price your broker may contact you to request additional margin.

Problem 2.19.
"Speculation in futures markets is pure gambling. It is not in the public interest to allow speculators to trade on a futures exchange." Discuss this viewpoint.

Speculators are important market participants because they add liquidity to the market. However, regulators generally only approve contracts when they are likely to be of interest to hedgers as well as speculators.

Problem 2.20.
Explain the difference between bilateral and central clearing for OTC derivatives.

In bilateral clearing the two sides enter into a master agreement covering all outstanding transactions. The agreement defines the circumstances under which transactions can be closed

out by one side, how transactions will be valued if there is a close out, how the collateral required by each side is calculated, and so on. In central clearing a CCP stands between the two sides in the same way that an exchange clearing house stands between two sides for transactions entered into on an exchange. The CCP requires initial and variation margin.

Problem 2.21.
What do you think would happen if an exchange started trading a contract in which the quality of the underlying asset was incompletely specified?

The contract would not be a success. Parties with short positions would hold their contracts until delivery and then deliver the cheapest form of the asset. This might well be viewed by the party with the long position as garbage! Once news of the quality problem became widely known no one would be prepared to buy the contract. This shows that futures contracts are feasible only when there are rigorous standards within an industry for defining the quality of the asset. Many futures contracts have in practice failed because of the problem of defining quality.

Problem 2.22.
"When a futures contract is traded on the floor of the exchange, it may be the case that the open interest increases by one, stays the same, or decreases by one." Explain this statement.

If both sides of the transaction are entering into a new contract, the open interest increases by one. If both sides of the transaction are closing out existing positions, the open interest decreases by one. If one party is entering into a new contract while the other party is closing out an existing position, the open interest stays the same.

Problem 2.23.
Suppose that on October 24, 2018, a company sells one April 2019 live-cattle futures contracts. It closes out its position on January 21, 2019. The futures price (per pound) is 121.20 cents when it enters into the contract, 118.30 cents when it closes out its position, and 118.80 cents at the end of December 2018. One contract is for the delivery of 40,000 pounds of cattle. What is the total profit? How is it taxed if the company is (a) a hedger and (b) a speculator? Assume that the company has a December 31 year end.

The total profit is

$$40{,}000\times(1.2120-1.1830) = \$1{,}160$$

If the company is a hedger this is all taxed in 2019. If it is a speculator

$$40{,}000\times(1.2120-1.1880) = \$960$$

is taxed in 2018 and

$$40{,}000\times(1.1880-1.1830) = \$200$$

is taxed in 2019.

Problem 2.24.
A cattle farmer expects to have 120,000 pounds of live cattle to sell in three months. The live-cattle futures contract traded by the CME Group is for the delivery of 40,000 pounds of cattle. How can the farmer use the contract for hedging? From the farmer's viewpoint, what are the pros and cons of hedging?

The farmer can short 3 contracts that have 3 months to maturity. If the price of cattle falls, the gain on the futures contract will offset the loss on the sale of the cattle. If the price of cattle rises, the gain on the sale of the cattle will be offset by the loss on the futures contract. Using futures contracts to hedge has the advantage that the farmer can greatly reduce the uncertainty about the price that will be received. Its disadvantage is that the farmer no longer gains from favorable movements in cattle prices.

Problem 2.25.
It is July 2017. A mining company has just discovered a small deposit of gold. It will take six months to construct the mine. The gold will then be extracted on a more or less continuous basis for one year. Futures contracts on gold are available with delivery months every two months from August 2017 to December 2018. Each contract is for the delivery of 100 ounces. Discuss how the mining company might use futures markets for hedging.

The mining company can estimate its production on a month by month basis. It can then short futures contracts to lock in the price received for the gold. For example, if a total of 3,000 ounces are expected to be produced in September 2018 and October 2018, the price received for this production can be hedged by shorting 30 October 2018 contracts.

Problem 2.26.
Explain how CCPs work. What are the advantages to the financial system of requiring CCPs to be used for all standard derivatives transactions between financial instituitions.?

A CCP stands between the two parties in an OTC derivative transaction in much the same way that a clearing house does for exchange-traded contracts. It absorbs the credit risk but requires initial and variation margin from each side. In addition, CCP members are required to contribute to a default fund. The advantage to the financial system is that there is a lot more collateral (i.e., margin) available and it is therefore much less likely that a default by one major participant in the derivatives market will lead to losses by other market participants. The disadvantage is that CCPs are replacing banks as the too-big-to-fail entities in the financial system. There clearly needs to be careful oversight of the management of CCPs.

Further Questions

Problem 2.27.
Trader A enters into futures contracts to buy 1 million euros for 1.1 million dollars in three months. Trader B enters in a forward contract to do the same thing. The exchange rate (dollars per euro) declines sharply during the first two months and then increases for the third month to close at 1.1300. Ignoring daily settlement, what is the total profit of each trader? When the impact of daily settlement is taken into account, which trader does better?

The total profit of each trader in dollars is $0.03 \times 1{,}000{,}000 = 30{,}000$. Trader B's profit is realized at the end of the three months. Trader A's profit is realized day-by-day during the three months. Substantial losses are made during the first two months and profits are made during the final month. It is likely that Trader B has done better because Trader A had to finance its losses during the first two months.

Problem 2.28.
Explain what is meant by open interest. Why does the open interest usually decline during the month preceding the delivery month? On a particular day, there were 2,000 trades in a particular futures contract. This means that there were 2000 buyers (going long) and 2000 sellers (going short). Of the 2,000 buyers, 1,400 were closing out positions and 600 were entering into new positions. Of the 2,000 sellers, 1,200 were closing out positions and 800 were entering into new positions. What is the impact of the day's trading on open interest?

Open interest is the number of contract outstanding. Many traders close out their positions just before the delivery month is reached. This is why the open interest declines during the month preceding the delivery month. The open interest went down by 600. We can see this in two ways. First, 1,400 shorts closed out and there were 800 new shorts. Second, 1,200 longs closed out and there were 600 new longs.

Problem 2.29.
One orange juice future contract is on 15,000 pounds of frozen concentrate. Suppose that in September 2017 a company sells a March 2019 orange juice futures contract for 120 cents per pound. At the end of December 2017 the futures price is 140 cents; at the end of December 2018 the futures price is 110 cents; and in February 2019 it is closed out at 125 cents. The company has a December 31 year end. What is the company's profit or loss on the contract? How is it realized? What is the accounting and tax treatment of the transaction if the company is classified as a) a hedger and b) a speculator?

The price goes up during the time the company holds the contract from 120 to 125 cents per pound. Overall the company therefore takes a loss of $15{,}000 \times 0.05 = \$750$. If the company is classified as a hedger this loss is realized in 2019, If it is classified as a speculator it realizes a

loss of 15,000×0.20 = $3000 in 2017, a gain of 15,000×0.30 = $4,500 in 2018, and a loss of 15,000×0.15 = $2,250 in 2019.

Problem 2.30.
A company enters into a short futures contract to sell 5,000 bushels of wheat for 750 cents per bushel. The initial margin is $3,000 and the maintenance margin is $2,000. What price change would lead to a margin call? Under what circumstances could $1,500 be withdrawn from the margin account?

There is a margin call if $1000 is lost on the contract. This will happen if the price of wheat futures rises by 20 cents from 750 cents to 770 cents per bushel. $1500 can be withdrawn if the futures price falls by 30 cents to 720 cents per bushel.

Problem 2.31.
Suppose that there are no storage costs for crude oil and the interest rate for borrowing or lending is 4% per annum. How could you make money if the June and December futures contracts for a particular year trade at $50 and $56?

You could go long one June oil contract and short one December contract. In June you take delivery of the oil borrowing $50 per barrel at 4% to meet cash outflows. The interest accumulated in six months is about 50×0.04×1/2 or $1 per barrel. In December the oil is sold for $56 per barrel which is more than the $51 that has to be repaid on the loan. The strategy therefore leads to a profit. Note that this profit is independent of the actual price of oil in June and December. It will be slightly affected by the daily settlement procedures.

Problem 2.32.
What position is equivalent to a long forward contract to buy an asset at K on a certain date and a put option to sell it for K on that date?

The long forward contract provides a payoff of $S_T - K$ where S_T is the asset price on the date and K is the delivery price. The put option provides a payoff of max ($K - S_T$, 0). If $S_T > K$ the sum of the two payoffs is $S_T - K$. If $S_T < K$ the sum of the two payoffs is 0. The combined payoff is therefore max ($S_T - K$, 0). This is the payoff from a call option. The equivalent position is therefore a call option.

Problem 2.33.
A company has derivatives transactions with Banks A, B, and C which are worth +$20 million, −$15 million, and −$25 million, respectively to the company. How much margin or collateral does the company have to provide in each of the following two situations?

a) The transactions are cleared bilaterally and are subject to one-way collateral agreements where the company posts variation margin, but no initial margin. The banks do not have to post collateral.
b) The transactions are cleared centrally through the same CCP and the CCP requires a total initial margin of $10 million.

If the transactions are cleared bilaterally, the company has to provide collateral to Banks A, B, and C of (in millions of dollars) 0, 15, and 25, respectively. The total collateral required is $40 million. If the transactions are cleared centrally they are netted against each other and the company's total variation margin (in millions of dollars) is –20 + 15 + 25 or $20 million in total. The total margin required (including the initial margin) is therefore $30 million.

Problem 2.34.
A bank's derivatives transactions with a counterparty are worth +$10 million to the bank and are cleared bilaterally. The counterparty has posted $10 million of cash collateral. What credit exposure does the bank have?

The counterparty may stop posting collateral and some time will then elapse before the bank is able to close out the transactions. During that time the transactions may move in the bank's favor, increasing its exposure. Note that the bank is likely to have hedged the transactions and will incur a loss on the hedge if the transactions move in the bank's favor. For example, if the transactions change in value from $10 to $13 million after the counterparty stops posting collateral, the bank loses $3 million on the hedge and will not necessarily realize an offsetting gain on the transactions.

Problem 2.35. (Excel file)

The author's Web page (www-2.rotman.utoronto.ca/~hull/data) contains daily closing prices for crude oil futures contract and gold futures contract. You are required to download the data for crude oil and answer the following:
(a) Assuming that daily price changes are normally distributed with zero mean, estimate the standard deviation of daily price changes. Calculate the standard deviation of two-day changes from the standard deviation of one-day changes assuming that changes are independent.
(b) Suppose that an exchange wants to set the margin requirement for a member with a long position in one contract so that it is 99% certain that the margin will not be wiped out by a two-day price move. (It chooses two days because it considers that it can take two days to close out a defaulting member.) How high does the margin have to be when the normal distribution assumption is made? Each contract is on 1,000 barrels of oil.
(c) Use the data to determine how often the margin of the member would actually be wiped out by a two-day price move. What do your results suggest about the appropriateness of the normal distribution assumption?

(d) Suppose that for retail clients the maintenance margin is equal to the amount calculated in (b) and is 75% of the initial margin. How frequently would the balance in the account of a client with a long position be negative immediately before a margin payment is due (so that the client has an incentive to default)? Assume that balances in excess of the initial margin are withdrawn by the client.

(a) For crude oil the standard deviation of daily changes is \$1.5777 per barrel or \$1577.7 per contract. The standard deviation of two-day price changes is $\$1577.7 \times \sqrt{2}$ = \$2,231.2 per contract.
(b) Margin for member =\$2,231.2×2.326 = \$5,190.6
(c) Worksheet shows that the margin would be wiped out 24 times or on 2.31% of the days. This suggests that price changes have heavier tails than the normal distribution.
(d) Worksheet shows that there would be 157 margin calls and the client has an incentive to default 9 times.

EXTRA PROBLEMS 2

1. In July 2012, a small chocolate factory receives a large order for chocolate bars to be delivered in November. The spot price for Cocoa is $2,400 per metric ton. It will need 10 metric tons of Cocoa in September to fill this order. Because of limited storage capacity and volatility in the world cocoa prices, the company decides the best strategy is to buy 10 call options for $53 each with strike price of $2,400 (equal to the current price) with a maturity date of September 2012. When the options expire in September, how much will the company pay (including the cost of the options) for cocoa if the spot price in September proves to be: a) $2,300, and b) $2,600? ($23,530, $24,530)

2. A trader invests in Facebook by buying 1000 shares in June for $27 per share. She also buys 1000 put options for $5 each as insurance in case the stock drops sharply. The put options have a strike price of $27 and a maturity date of December. What is the gain or loss if the spot price on December is: a) $20, b) $27, c) $32 and d) $37? ($5,000 loss, $5,000 loss, $0, $5,000 gain)

3. The spot price for Google stock is $578 on June 6. A trader considers two alternatives: buy 100 shares of the stock, or buy 100 European call options on Google for $38 each with a strike price of $575 and maturity date of September 2012. For each alternative, what is: a) the upfront cost? b) the total gain if the stock price at maturity is $650? c) the total loss if the stock price is $500 at maturity? ($57,800 and $3,800; $7,200 and $3,700; -$7,800 and -$3,800)

4. A trader takes the long position and a hedge fund takes a short position on ten 1-month S&P 500 futures contracts at 1300. A single S&P 500 futures contract equals ($250) x (Index Value). The initial margin is $325,000 and the maintenance margin is $245,000 for both accounts. Ten trading days later, the futures price of the index drops to 1,260 triggering a margin call for the trader. What is the change margin account balance (indicate gain or loss) for: a) the trader and b) the hedge fund? What is the margin call for the trader? (trader: $100,000 loss, hedge fund: $100,000 gain, margin call: $100,000)

5. A speculator sells a July 2013 wheat futures contract at 721 cents per bushel. Each futures contract is for 5,000 bushels. The futures price drops to 676 on December 31, 2012 and rises to 712 in May 2013 when she closes the contract. What is the gain or loss for accounting purposes in 2013? ($180,000 loss)

6. In December 2011, a company expects to buy 100,000 MMBtu of natural gas before the end of March 2012, but does not know exactly when. To hedge against volatile gas prices, it implements a rolling forward hedge by taking a long position on 10 two-month natural gas futures (only held for 1 month). One futures contract is for 10,000 MMBtu and is quoted in $ per MMBtu. The commodity is purchased in March 2012. What is total dollar gain/loss from the rolling hedge? Assume a hedge ratio of 0.8.

($84,000 loss)

Date	Dec 2011	Jan 2012	Feb 2012	Mar 2012
Feb 2012 Futures Price	3.65	3.00	-	-
Mar 2012 Futures Price	-	2.95	2.70	-
Apr 2012 Futures Price	-	-	2.65	2.50
Spot Price	3.67			2.50

7. A trader owns 55,000 troy oz of silver and decides to hedge with 6-month silver futures contracts. The silver spot price is $28.7 per troy ounce and the six-month futures price is $26.7 per troy ounce. Each futures contract is on 5,000 troy oz. The standard deviation of the change in the spot price of silver is 0.43. The standard deviation of the change in silver futures prices is 0.40. The coefficient of correlation between the two is 0.95.
    a. What is the minimum variance hedge ratio?
    b. What is the optimal number of futures contracts without tailing the hedge?
    c. What is the optimal number of futures contracts with tailing the hedge? (1.02, 11.23, 12.08)

8. For an interest rate compounded annually of 7%, what is the equivalent interest rate compounded: (6.88%, 6.82%, 6.78%, 6.77%, 6.77%)
    a. Semi-annually
    b. Quarterly
    c. Monthly
    d. Weekly
    e. Daily

9. Given the zero rates and cash flows for a bond (see table below):
    a. What is the theoretical price? ($986.23)
    b. What is the bond yield? (3.19%)

Maturity(Years)	Treasury Zero Rates (%)	Coupon Payments	Principal
0.5	2.0%	$10	-
1.0	2.3%	$15	-
1.5	2.7%	$10	-
2.0	3.2%	$15	$1000

10. A stock provides a dividend yield of 5.0% paid semi-annually (equivalent to 4.94% continuously compounded). The spot price of the stock is currently $500, and the risk-free rate is 7.5% with continuous compounding.
    a. What is the two-year forward price for a stock? ($526.27)
    b. What is the continuously compounded cost of carry for the stock? (2.56%)

11. A US investor sees an arbitrage opportunity in the currency markets. The spot exchange rate between the Swiss Franc and US Dollar is 1.0404 ($ per CHF). Assume the continuously compounded interest rates in the US and Switzerland are 0.25% and 0%, respectively. The 3-month currency forward price is 1.0300 ($ per CHF). What is the theoretically correct forward price? What is the investor's total profit (in CHF), assuming she begins by borrowing 1,000 CHF? (1.04105, 10.73)

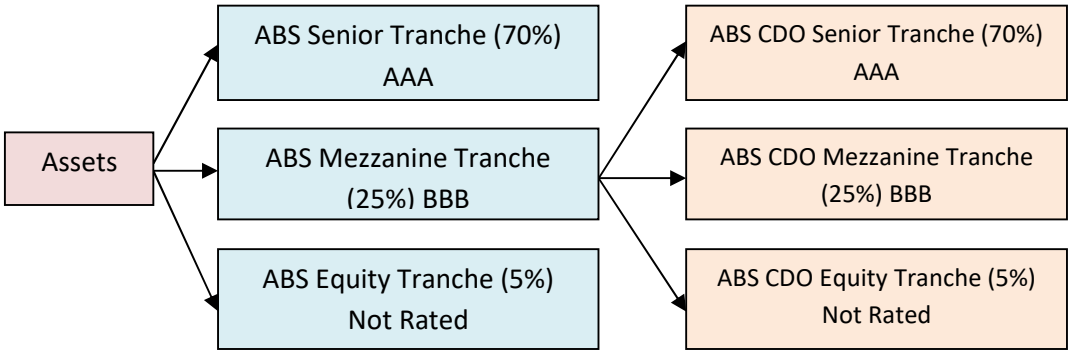
12. Continuously compounded LIBOR rates per annum for 6, 12, and 18-months are given in the table below. The 2-year swap rate is 3% per annum with payments made semi-annually. What is the 2-year LIBOR/swap zero rate for 2 years? Use LIBOR discounting (2.99%)

Maturity (Years)	LIBOR/Swap Zero Rates (%)
0.5	2.0%
1.0	2.4%
1.5	2.6%
2.0	?

13. Consider a currency swap with 3 years remaining. A financial institution receives 3.0% per annum in sterling (GBP) and pays 1.5% per annum in dollars once a year. The LIBOR/swap interest rate with continuous compounding is flat in both countries. The British rate is 2.5% per annum and the US rate is 2.0% per annum. The principal amounts are £10 million pounds and $15 million dollars, and the current exchange rate is $1.5 = £1. By valuing the currency swap as fixed-rate bonds, what is:
    a. The value of the dollar bond in $? ($14.78 Million)
    b. The value of the sterling bond in £? (£10.13 Million)
    c. The value of the currency swap in $? ($0.4255 Million)

14. Given the ABS & ABS CDO shown, what is the minimum loss on the portfolio of underlying assets when
    a. Lower two ABS tranches have a 100% loss of principal? (30%)
    b. Senior ABS tranche a 50% has loss of principal? (65%)
    c. Equity ABS CDO tranche has a 100% loss of principal? (6.25%)
    d. Mezzanine ABS CDO tranche has a 100% loss of principal? (12.5%)
    e. Senior ABS CDO tranche has a 50% loss of principal? (21.25%)

f. Senior ABS CDO tranche has a 100% loss of principal? (30%)



15. An investor buys 5 call option contracts, each on 100 shares with a strike of 60. There is a 6-for-5 stock split. Give the following:
    a. The new strike price (50)
    b. The new number of shares underlying the 5 contracts (600)

16. The price of a European call and put on a stock are $2 and $5, respectively. Both have a strike price of $45 and an expiration date of 6 months. The current price of the underlying non-dividend-paying stock is $40. What is the implied risk-free interest rate? (9.09%)

17. An investor creates a *butterfly spread* by trading 9-month call options with strike prices of $115, $125, and $135. The prices of the options are $20.50, $14.50, and $9.50, respectively. (Note: Total payoff does not include initial investment)
    a. What is the initial investment? ($1 paid out)
    b. What is the total payoff when the stock price in 9 months is 110? ($0)
    c. What is the total payoff when the stock price in 9 months is 120? ($5)
    d. What is the total payoff when the stock price in 9 months is 125? ($10)
    e. What is the total payoff when the stock price in 9 months is 128? ($7)
    f. What is the total payoff when the stock price in 9 months is 140? ($0)

18. A 1-year option is offered on a non-dividend-paying stock. The stock price is $85. The exercise price of the option is $90 and the volatility is 18% per annum. The continuously compounded risk-free rate is 6% per annum. When the Black-Scholes-Merton model is used
    a. What is the value of d_1? (0.106)
    b. What is the value of d_2? (-0.074)
    c. What is the price of a call option, c? ($6.21)
    d. What is the price of a put option, p? ($5.97)

Now, assume that the stock pays a dividend after 3-months and 9-months of $1.50.

e. What is the present value of the dividends? ($2.91)
f. What is the new value of d_1 with dividends? (-0.088)
g. What is the new value of d_2 with dividends? (-0.268)
h. What is the value of a call option? ($4.74)

19. Discuss the pros and cons of executive stock options versus paying executives directly with stock.

Executive stock options are sometimes referred to as an executive's "pay for performance." If the company's stock price goes up, so that shareholders make gains, the executive is rewarded. However, this overlooks the asymmetric payoffs of options. If the company does badly then the shareholders lose money, but all that happens to the executives is that they fail to make a gain. Unlike the shareholders, they do not experience a loss. Many people think that a better type of pay for performance is a *restricted stock unit*. This entitles the executive to own a share of the company's stock at a particular future time (the vesting date). The gains and losses of the executives then mirror those of other shareholders. It is sometimes argued that the asymmetric payoffs of options can lead top senior executives taking risks they would not otherwise take. This may or may not be in the interests of the company's shareholders.

20. A two-step binomial tree is used to value an option on the Australian dollar. The strike price is 1.00 USD per AUD and the expiration date is in 6 months. Each step is 3 months. The current price of one AUD is 1.04 USD. The US risk free rate is 2.0%, and the AUD risk-free rate is 2.5%. The exchange rate has a volatility of 6% per annum.
    a. What is the proportional up movement, u, for the currency? (1.0305)
    b. What is the probability of an up movement, p? (0.4717)
    c. What is the price of an American call option on the currency? ($0.0427)

21. The spot price of an index is 250. The dividend yield on the index is 3% per annum. The risk free rate is 4%. If price of a 3-month European call option is $16 when the strike price is 240, what is the implied volatility per annum? (20.4%)

22. Use Black's model to value a European put option on the spot price of a commodity when the strike price is $30 and the expiration is in 12 months. The current futures price of commodity for a contract lasting 12 months is $35. The risk free rate is 5% per annum and the volatility is 25%. ($1.26)

23. A trader decides to hedge her portfolio against large market moves by taking positions in the underlying asset and two options (see table below).
    a. How many units of options 1 and 2, respectively, are needed to make the portfolio gamma and vega neutral? (300, -25)
    b. How many units of the underlying asset are needed to make the hedged

portfolio delta neutral (indicate long/short position)? (11 long)

	Delta	Gamma	Vega
Portfolio	0.50	-1000	-500
Option 1	-0.03	10	2.5
Option 2	0.10	80	10

24. A trader decides to protect her portfolio with a put option. The portfolio is worth $150 million and the required put option has a strike price of $145 million with a maturity of 24 weeks. The volatility of the portfolio is 15% and the dividend yield on the portfolio is 3% per annum. The risk-free rate is 4%. Because the option is not available on exchanges, the trader decides to create an option by maintaining a position in the underlying portfolio with the required delta. What percentage of the original portfolio should be sold and invested at the risk-free rate:
    a. Initially at time zero? (sell 32.9%)
    b. After one week, when value is $145 million? (sell an additional 12.7%)
    c. After two weeks when value is $148 million? (buy back 7.99%)

25. A Cox-Ross-Rubinstein binomial tree is used to value an option on the Dow Jones Industrial Average (DJIA) index. The dividend yield is 3% per annum, the index volatility is 14% per annum, the time step is 2 months, and the risk-free interest rate is 5% per annum. What is the probability of an up move? (0.5149)

Hull: Options Futures and Other Derivatives, 10th Edition
Notes for Instructors

This document contains notes on each chapter of Options, Futures, and Other Derivatives, tenth edition. These notes make some suggestions on the teaching of the chapters and mention some of the differences between the 9th and 10th editions.

Instructors should be aware that solutions to end-of chapter problems in all textbooks in all subjects tend to have found their way to the web. This textbook is unfortunately no exception. I have found that very few of my students search the web for solutions to problems, but other instructors tell me that they regard this as a serious issue. To overcome the problem, I suggest handing out assignments sets where either

(a) The assignments you use are similar to the end-of-chapter problems, but the numbers in the problems and the wording of the problems have been changed The Problem Solutions in the instructor support material for the book contains *.doc files with both the end of chapter problems and their solutions. You can cut and paste from these files; or

(b) The assignment questions you use are taken from the "additional problems" included with this instructor material. For these I provide only the answers, not how they are derived. Even if a student finds the answer on the web, (s)he still has to work out where it comes from.

CHAPTER 1
Introduction

This chapter introduces the markets for futures, forward, and option contracts and explains the activities of hedgers, speculators, and arbitrageurs. It explains the new regulations for OTC markets introduced since the crisis and the role of CCPs. Issues concerning futures contracts such as margin requirements, settlement procedures, the role of the clearinghouse, etc are covered in Chapter 2.

Some instructors prefer to avoid any mention of options until the material on linear products in Chapters 1 to 7 has been covered. I like to introduce students to options in the first class, even though they are not mentioned again for several classes. This is because most students find options to be the most interesting of the derivatives covered and I like students to be enthusiastic about the course early on.

The way in which the material in Chapter 1 is covered is likely to depend on the backgrounds of the students. If a course in investments is a prerequisite, Chapter 1 can be regarded as a review of material already familiar to the students and can be covered fairly quickly. If an investments course is not a prerequisite, more time may be required. Increasingly, some aspects of derivatives markets are being covered in introductory corporate finance courses, accounting courses, strategy courses, etc. In many instances students are, therefore, likely to have had some exposure to the material in Chapter 1. I do not require an investments elective as a prerequisite for my elective on futures and options markets and find that $1\frac{1}{2}$ to 2 hours is necessary for me to introduce the course and cover the material in Chapter 1.

To motivate students at the outset of the course, I discuss the growing importance of derivatives, how much experts in the field are paid, etc. It is not uncommon for students

who join derivatives groups, and are successful, to earn (including bonus) several hundred thousand dollars a year—or even $1 million per year—three or four years after graduating. The role of derivatives in the crisis and the Lehman's bankrupty is likely to come up. I defer a discussion of the crisis until the Chapter 8 material is covered.

Towards the end of the first class I usually produce a current newspaper and describe several traded futures and options. I then ask students to guess the quoted price. Sometimes votes are taken. This is an enjoyable exercise and forces students to think actively about the nature of the contracts and the determinants of price. It usually leads to a preliminary discussion of such issues as the relationship between a futures price and the corresponding spot price, the desirability of options being exercised early, why most options sell for more than their intrinsic value, etc.

While covering the Chapter 1 material, I treat futures as the same as forwards for the purposes of discussion. I try to avoid being drawn into a discussion of such issues as the mechanics of futures, margin requirements, daily settlement procedures, and so on until I am ready. These topics are covered in Chapter 2.

As will be evident from the slides that go with this chapter, I usually introduce students to a little of the Chapter 5 material during the first class. I discuss how arbitrage arguments tie the futures price of gold to its spot price and why the futures price of a consumption commodity such as oil is not tied to its spot price in the same way. Problem 1.35 can be used to initiate the discussion.

I find that Problems 1.36 and 1.40 work well as an assignment questions. (1.40 has the advantage that it introduces students to DerivaGem early in the course.) Problem 1.37 usually generates a lively discussion. I sometimes ask students to consider it between the first and second class. We then discuss it at the beginning of the second class. The other further questions can be used either as assignment questions or for class discussion.

CHAPTER 2
Futures Markets and Central Counterparties

This chapter explains the functioning of futures markets. I do not spend a great deal of time in class going over most of the details of how futures markets work. I let students read these for themselves. But I do find it worth spending some time going through Table 2.1 to explain the way in which margin accounts work. After the essentials of the operations of futures markets have been explained, I ask students to consider Problem 2.22 in class because I find that this often reveals gaps in their understanding. I usually use about $1\frac{1}{2}$ hours to cover the material in the chapter.

In many ways, OTC markets are becoming more like exchange-traded markets as a result of post-crisis regulation. Once the way margin accounts are used for futures has been explained it is natural to talk about how collateralization works in the OTC market (see Section 2.5). The new title to this chapter reflects the fact that CCPs are very like futures clearing houses.

There are many ways of making a discussion of futures markets fun. An easy-to-organize trading game that was explained to me by a Wall Street training manager works as follows. The instructor chooses two students to keep trading records on the front board and divides the rest of the students into about ten groups. Each group is given an identifier

(e.g., A, B, C, etc) and a card with the identifier shown in big letters. They display the card when they want to make trades. The instructor chooses a seven-digit telephone number, but does not reveal this to students. The groups trade the sum of digits of the telephone number by entering long or short positions. For example, group B might bid (i.e. offer to buy) at 35. If this is accepted by another group (say group D), the record keepers show that B is long one contract at 35 and D is short one contract at 35. (If the actual sum of digits is 32, B is -3 on the trade and D is $+3$.) The instructor controls the trading, asks for bids or offers as appropriate, and shouts trades to the record keepers. Every two minutes the instructor reveals one of the digits of the number. This game nearly always works very well for me. Trading typically starts slowly and then becomes very intense. The game gives students a sense of what futures trading is like. (I insist that they use the words bid and offer rather than buy and sell.) It shows how prices are formed in markets. After the game is over we discuss how the market price moved during the game. The records also usually show different trading strategies. Some groups are usually speculators (all trades are long or all are short) and others are like day traders (e.g., buy at 35, sell at 36, buy at 38, sell at 39, etc). I point out to students that we need both types of traders to make the market work.

There are many stories that can be told about futures markets. Students are often interested in attempts to corner markets. I explain that the Hunt brothers' exploits in the silver market (See footnote 8 in Section 2.9) bankrupted them because the exchange forced them to close out their positions prior to the delivery month and as a result the price dropped. The brothers tried unsuccessfully to sue the exchange.

Business Snapshot 2.1 is an amusing story that I have often told in class. Business Snapshot 2.2 (on Long Term Capital Management) fits in well when the operation of margin accounts is being explained.

Problems 2.27 to 2.34 can be used as relatively straightforward hand-in assignments. Problem 2.35 has been changed for this edition to make it more manageable and a more useful learning experience.

CHAPTER 3
Hedging Strategies Using Futures

This chapter discusses how long and short futures positions are used for hedging. It covers basis risk, hedge ratios, the use of stock index futures, and stack and roll strategies. The discussion of tailing the hedge has been improved for this edition.

As will be evident from the slides, I cover the material in the chapter in the order in which it is presented. The section on arguments for and against hedging often generates a lively discussion. It is important to emphasize that the purpose of hedging is to reduce the standard deviation of the outcome, not to increase its expected value. I usually discuss Problem 3.17 at some stage to emphasize the point that, even in relatively simple situations, it is easy to make incorrect hedging decisions when you do not look at the big picture.

Business Snapshot 3.1 discusses hedging by gold mining companies. I use this to emphasize the importance of communicating with shareholders. I also like to discuss how investment banks hedge their risks when they enter into forward contracts with gold producers. (This is the second part of Business Snapshot 3.1.) I also like to ask students

about the determinants of gold lease rates. If more gold producers choose to hedge, does the gold lease rate go up or down? (The answer is that it goes up because there is a greater demand on the part of investment banks for gold borrowing.)

Any of the Problems 3.24 to 3.32 can be used as assignment questions. My favorite is Problem 3.32.

CHAPTER 4
Interest Rates

This chapter now introduces swaps. It covers the OIS rate and explains that OIS rates are used as proxies for risk-free rates when derivatives are valued. (In the 9th edition this material was in Chapter 9.) The example for determining Treasury zero rates has been changed and an example showing how OIS zero rates can be determined has been included.

I like to spend a some time explaining compounding frequency issues. I make it clear to students that we are talking about nothing more than a unit of measurement for interest rates. Moving from quarterly compounding to continuous compounding is like changing the unit of measurement of distance from miles to kilometers. When students are introduced to continuous compounding early in a course, I find they have very little difficulty with it.

The first part of the chapter discusses zero rates, bond valuation, bond yields, par yields, and the calculation of Treasury and OIS zero curves. The slides mirror the examples in the text. When covering the bootstrap method to calculate zero curves, I point out that the bootstrap method is a very popular approach, but it is not the only one that is used in practice. For example, some analysts use cubic or exponential splines.

I spend some time on the relationship between spot and forward interest rates and combine this with a discussion of FRAs and theories of the term structure. I explain that it is possible to enter into transactions that lock in the forward rate for a future time period and then discuss the Orange County story (Business Snapshot 4.1). Orange County entered into contracts (often highly levered) that paid off if the forward rate was higher than the realized future spot rate (An example of such a contract is an FRA where fixed is received and floating is paid). This worked well in 1992 and 1993, but led to a huge loss in 1994.

Sections 4.10 and 4.11 cover duration and convexity. Duration is a widely used concept in derivatives markets. The chapter explains that the $\Delta B/B = -D\Delta y$ relationship holds when rates are continuously compounded. When some other compounding frequency is used the same relationship is true provided D is defined as the modified duration. I like to illustrate the truth of the duration relationship with numerical example similar to those in the text.

Problems 4.25 to 4.34 can be used as assignment questions. My favorites are 4.32, 4.33, and 4.34.

CHAPTER 5
Determination of Forward and Futures Prices

This chapter covers the relationship between forward/futures prices and spot prices. The approach used in the chapter is to produce results for forward prices first and then argue that futures prices are very close to forward prices. The early part of the chapter explains short selling and the difference between investment and consumption assets.

I usually go through the material in Section 5.4 fairly carefully to make sure that students understand the nature of the arguments that are used. (Business Snapshot 5.1, a description of Joseph Jett's trading at Kidder Peabody, helps to explain why equation 5.1 holds.) I then go through Sections 5.5 and 5.6 fairly quickly because the arguments in those sections are really just extensions of the argument in Section 5.4. However, it is necessary to explain carefully the difference between a known cash income and a known yield.

When covering Section 5.7, I emphasize the distinction between f (the value of a long forward contract) and F_0 (the forward price). This often causes confusion. I like to go through Business Snapshot 5.2 to help students understand the issue.

The material in Sections 5.9 and 5.10 follows naturally from the material in Sections 5.4 to 5.6. I try to illustrate all of the formulas with numerical examples taken from current market quotes. The interpretation of a foreign currency as an investment providing a yield equal to the foreign risk-free rate needs to be explained carefully. I also like to spend some time discussing the fact that the variable underlying the CME Nikkei futures contract is not something that can be traded (see Business Snapshot 5.3).

It is important that students understand the distinction between assets that are held solely for investment by a significant number of investors and those that are not. This distinction is made right at the beginning of the chapter.

Section 5.14 ties the relationship between a futures prices and an expected future spot price to the notion of systematic risk, which will probably be familiar to students from other courses they have taken.

Problems 5.26 to 5.34 can be used for assignments or discussion in class. My favorite assignment questions are 5.31 and 5.33.

CHAPTER 6
Interest Rate Futures

This chapter discusses how interest rate futures contracts are quoted, how they work, and how they are used for hedging. I start by discussing the material in Sections 6.1 and 6.2 on day counts and how prices are quoted in the spot market. (It is fun to talk about Business Snapshot 6.1 when day count conventions are discussed.) I like to spend some time making sure students are comfortable with the Treasury bond futures contracts and the Eurodollar futures contract. In the case of the Treasury bond futures contract they should understand where conversion factors come from, the cheapest-to-deliver bond calculations, and the wild card play (see Business Snapshot 6.2). In the case of Eurodollar futures they should understand the quotation system, that the contract's value changes by \$25 for each basis point change in the quote, and how the final cash settlement works.

Students should also appreciate that a convexity adjustment is necessary to calculate a forward rate from a Eurodollar futures quote. They will not (at least at this stage) understand where equation 6.3 comes from, but they should understand that there are two reasons why forward and futures interest rates are different. The first is that futures are settled daily; forwards are not. The second is that futures (if not daily settled) would provide a payoff at the beginning of the period covered by the rate; forwards provide a payoff at the end of the period covered by the rate. (The payoff from a forward contract can be at the beginning of the period, but it is the present value of the payoff that would normally happen at the end of the period.)

The final part of the chapter covers the use of interest rate futures for duration-based hedging. I usually illustrate this material with a numerical example.

Problems 6.23 to 6.31 can be used as assignment questions. My favorites are 6.30, and 6.31.

CHAPTER 7
Swaps

This chapter covers the nature of swaps and how they are valued. It has been rewritten for the 10th edition. (Chapter 7 of the 9th edition employed LIBOR with OIS discounting being discussed in Chapter 9.) OIS discounting has now become the standard approach to valuing derivatives. (I explain this by saying that OIS is a better proxy for the risk-free rate than LIBOR, but many practitioners would argue that OIS discounting is simply a reflection of the interest paid on cash collateral.) As a result, the valuation material in this chapter is simpler. The examples in the chapter have been changed to emphasize the role of banks and other financial intermediaries

I believe that it makes sense to teach swaps soon after forward contracts are covered because a swap is nothing more than a convenient way of bundling forward contracts. However, other instructors may have other preferences as far as this is concerned and the Chapter 7 material can be taught later in a course if desired. The growth of the swaps since the early 1980s makes them one of the most important derivative instruments. This chapter covers interest rate and currency swaps. Credit default swaps and nonstandard swaps are briefly covered at the end of this chapter and in more detail in Chapters 25 and 34.

After explaining how swaps work and the way they can be used to transform assets and liabilities, I present the traditional comparative advantage argument for plain vanilla interest rate swaps and then proceed to explain why it is flawed. This usually generates a lively discussion. The key point is that the comparative advantage argument compares apples with oranges. Suppose a BBB-rated company wants to borrow at a fixed rate for five years and can choose between a fixed rate of 8% and a floating rate of LIBOR+1%. Borrowing floating and swapping to fixed appears attractive. But this ignores a key point. A fixed-rate loan will lead to exactly the same rate of interest applying each year for five years. By contrast, the spread over LIBOR on the floating-rate loan usually applies for the first accrual period. If the creditworthiness of the company declines, the rate is liable to increase when the loan is rolled over. This means that borrowing floating and swapping to fixed subjects the BBB to "rollover risk". For us to be comparing apples to apples

the spread over LIBOR must be guaranteed for the whole life of the swap. (Instruments known as note issuance facilities do this and when they are used the comparative advantage disappears.)

A possible exercise is to take a situation such as that shown in Figure 7.8 and ask students to identify the credit risk and rollover risk of AAACorp, BBBCorp, and the financial institution.

Some of the material previously in this chapter on the nature of swap rates has been moved to Chapter 4 in the 10th edition.

In the case of currency swaps the exchange of principal needs to be explained. Fixed-for-fixed currency swaps allow either a "portfolio-of-forwards" or an "exchange-of bonds" approach to valuation to be used, as illustrated in Examples 7.3 and 7.4. (Note that with OIS discounting, a simple exchange of bonds argument does not work for fixed-for-floating LIBOR swaps)

Some of the end-of-chapter problems have had to be changed to reflect OIS discounting. All the further questions can be used as assignment questions. I usually require students to hand in two of them.

Chapter 8
Securitization and the Credit Crisis of 2007

The credit crisis is (hopefully) the biggest financial upheaval this generation will see. It is not surprising that students want to talk about the crisis, what went wrong, why, whether it will happen again, etc. I find it useful to talk about these issues in a fairly structured way early in a course so that I can return to particular points or expand on them later in the course when appropriate. This is why the credit crisis material appears relatively early in the book.

In addition to discussing the credit crisis, Chapter 8 explains securitization, which is an important tool for transferring credit risk from one entity to another in the economy.

The chapter starts by explaining ABSs and ABS CDOs. It makes the point that the senior tranche of an ABS CDO is more risky than the senior tranche of an ABS. (Indeed the senior tranches of most ABS CDOs that were created from subprime mortgages were worth nothing in 2009 whereas the senior tranches of ABSs had some value.) The chapter then moves on to discuss the causes of the house price bubble in the U.S. and the factors that led the bubble to burst. Finally it reviews what went wrong and some of the regulatory changes. Some instructors may well wish to spend more time than I do discussing the work of the Basel committee and Dodd-Frank.

Problems 8.16, 8.18 and 8.20 are possible assignment questions. Problems 8.17 and 8.19 can be used for class discussion.

Chapter 9
XVAs

Much of the material that was previously in Chapter 9 (discussion of the risk-free rate, how OIS contracts work, OIS vs. LIBOR discounting, etc) is now in earlier chapters. This chapter now focusses on certain adjustments (CVA, DVA, FVA, MVA, and KVA) that have become very important for derivatives dealers. It explains the adjustments and discusses their theoretical validity.

CVA and DVA are theoretically correct adjustments. DVA often causes problems because it seems counterintuitive that the possibility of a bank defaulting can lead to a benefit to the bank. But the bottom line is that derivatives are zero sum games. DVA is the counterparty's CVA. Given that it is a cost to the counterparty it must be a benefit to the bank. The calculation of CVA and DVA is discussed further in Chapter 24.

FVA, MVA, and KVA have theoretical weaknesses. Some instructors make like to use these adjustments as vehicles to review some theoretical concepts in corporate finance. Others may prefer to explain market practice and why it is considered that the adjustments should be made.

Problem 9.13 is appropriate for class discussion (to cover the corporate finance issues). Problem 9.14 can be used as an assignment.

CHAPTER 10
Mechanics of Options Markets

This chapter provides information on how options markets work. I usually go through the chapter fairly quickly leaving students to read the details for themselves. Points I spend time on are the payoffs from the four option positions and how the terms of options change when there are dividends and stock splits.

Problems 10.27 and 10.29 work well for class discussion. Other further questions can be used as assignment questions.

CHAPTER 11
Properties of Stock Options

This chapter outlines a number of relationships between a stock option price and the underlying stock price that do not involve any assumptions about the volatility of the stock's price. As will be evident from the slides, I like to present students with sets of numerical data for c, C, p, P, S_0, K, r, T, and D that violate the relationships in the chapter and ask them what trades they would do. This usually results in good classroom interaction.

I devote most time in class to

1. The $c \geq S_0 - Ke^{-rT}$ result
2. The early exercise arguments for American calls
3. The put–call parity result for European options

When discussing the early exercise of American calls on non-dividend-paying stocks I present students with a situation where the option is deep-in-the-money ($S_0 = 100$; $T = 0.25$; $K = 60$) and ask whether they would exercise early when (a) they want to keep the stock as part of their portfolio and (b) when they do not. In the first case, they should delay exercise and thereby delay paying the strike price. In the second case they should sell the option to an investor who does want to keep the stock as part of his or her portfolio. (Such an investor must exist as otherwise the stock price would not be \$100). This investor will pay at least 100 minus the present value of 60 for the option. The above argument shows that, if the possibility of the stock price falling below \$60 is ignored, the option should not be exercised early. When the possibility of the stock price falling below \$60 is recognized, we become even less inclined to exercise early.